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APPLIED HYDRAULICS

THE MAGAZINE OF FLUID POWER TRANSMISSION

UGUST, 1949

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- HYDRAULIC CONTROLS
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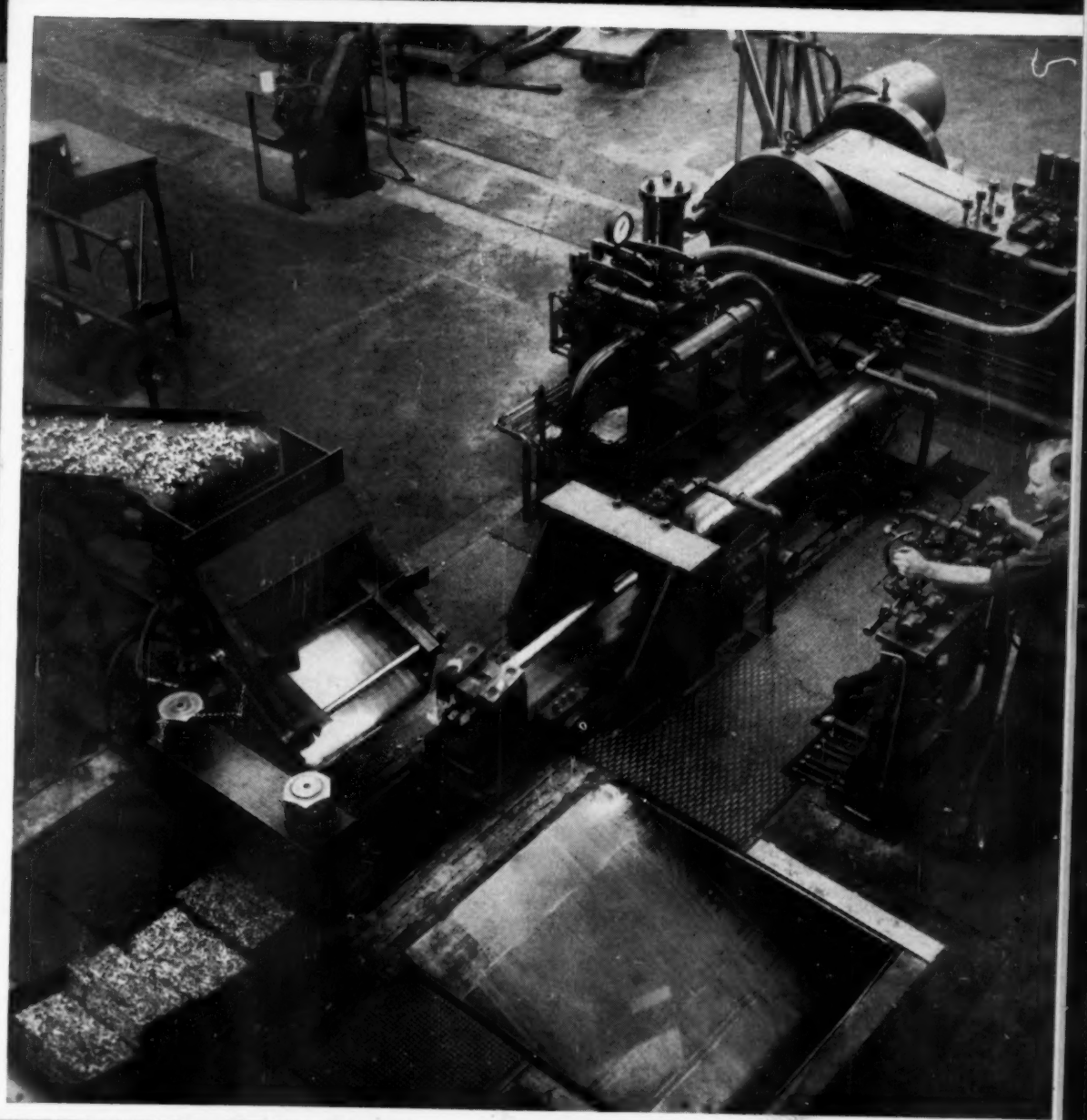

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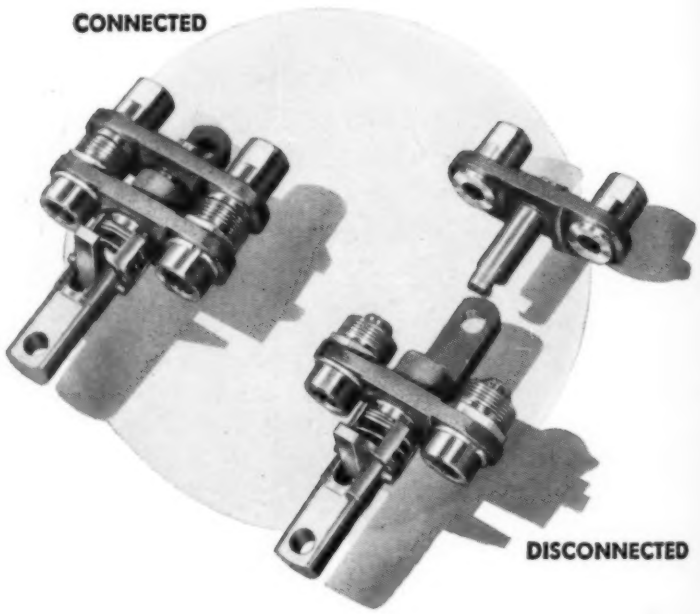

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FRONT COVER: A view of the hydraulic baler at the Copper Wire Division, Westinghouse Electric Corporation, Buffalo, N. Y. Chips from the initial shaving operation on the copper rod are carried by conveyor to baler which bales and ejects them.

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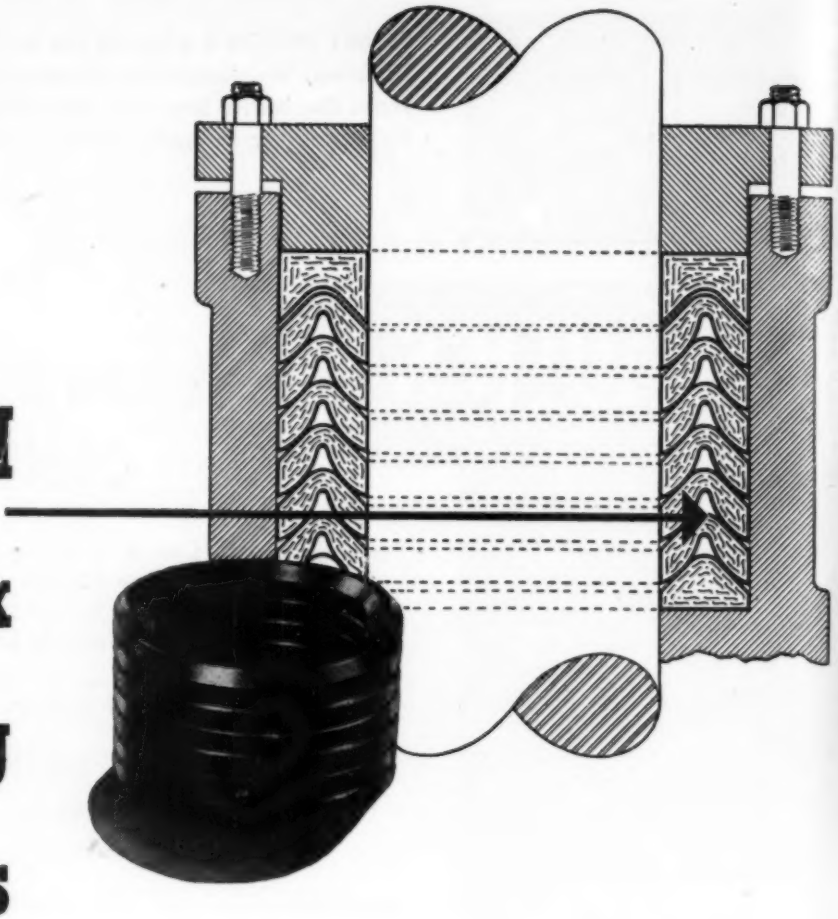
R/M Vee-Flex packing rings



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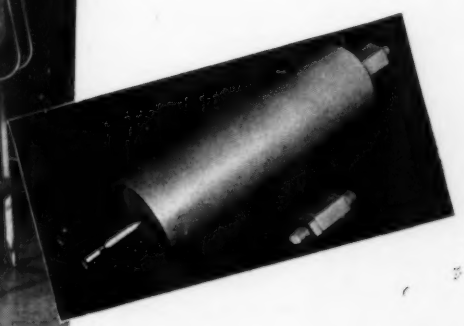

The Ozalid "Super B" printmaking machine, shown with the Electrol hand pump and check valve, which are used in the developer unit.

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FOR BETTER HYDRAULIC DEVICES

FOUR SECOND

By WALTER R. ELLIS
Compressed Air Products
Newark, N. J.

Fig. 1. The die closing cylinder and built-in intensifier (top) was the only special unit in the system. All other components were standard items.

ONE OF OUR CUSTOMERS UTILIZES huge numbers of die cast rivets which are assembly pieces for standard handbag frames. They do their own die casting on three machines which were unable to keep up with the demand or the ability of other departments in the plant to turn out greater numbers of finished pieces. A solution finally arrived at was to incorporate a low pressure operated intensifier assembled integrally with the die closing cylinder. This made it possible to reduce complete machine cycles to four seconds or less and meet a minimum requirement of 900 shots per hour.

This company operates a bank of three die casting machines from a common pumping system, each machine being equipped with a gas-charged accumulator. Although the problem of designing the hydraulic and air systems for such short die casting cycles seemed routine, initial calculations quickly proved otherwise.

To meet the minimum requirement of 900 shots per hour, necessitated that a complete operating cycle, including the time required by the operator for re-cycle control and the ejection of work pieces, be held to four seconds or less. This required a careful division and allotment of time for each sequence of operation.

The indicated sequence of operation was conventional:

(a) Rapid, low pressure approach stroke of die clamping cylinder

(b) Development of required tonnage to assure safe clamping effort

(c) Shot cylinder injection stroke

(d) Dwell period (clamp and shot cylinders under full pressure)

(e) Retraction of shot cylinder

(f) Retraction of clamp cylinder.

The weight—eight ounces—and the projected area of the pieces indicated a die clamping force of 30,000 to 40,000 pounds to resist flashing of the dies. With space restricted, a double acting die closing cylinder of 3½ in bore was chosen to operate at a final hydraulic pressure of 3000 to 4000 psi.

As a conventional air cylinder was to be used for making the injection shot, the major hydraulic problems were confined to the die closing cylinder and the pumping equipment required.

A 40 gpm pump was chosen as adequate to provide the low pressure fast traversing cylinder speed required to meet the timing of the cycle. A standard package unit, driven by a 15 hp 1200 rpm motor, mounted on a 100 gallon reservoir, with relief valve, pressure gage, oil filter and internal piping was selected. Water cooling is employed to prevent overheating of the oil.

The very rapid approach speed provided by the low pressure pump system, without some form of cushioning, would have resulted in damaging impact of the dies upon closing. A cam operated flow control or decelerator valve was incorporated in the circuit to function at a point near the end of the die closing stroke. This cushioning time was included in the overall timing calculations.

The only indicated remaining problem, other than the choice of valving components, was the generation of the 3000 to 4000 psi necessary for full clamping. Obviously, this had to be done very quickly.

Originally, a "high-low", double pump, two pressure system was planned. However, the usual small high pressure pump contemplated to provide final clamping pressure required too much time to generate pressures from zero to 3000 psi or over to provide for a four second cycle.

In addition a central pumping system for three machines must be located at some distance from the machines, involving relatively long pipe lines. Stressing such lines to bring the system to required high pressure would consume several seconds.

Built-in Intensifier

Obviously, the conventional two pressure, dual pump system was not the answer. Quickly localizing high pressure was possible and practical

NDCYCLE DIE CASTING

A four second or shorter cycle for die casting shots of eight ounces was made possible by the use of a low pressure operated intensifier assembled integrally with the die closing cylinder.

with a low pressure operated intensifier assembled integrally with the die closing cylinder. Such a unit was designed and built (Figure 1).

This device eliminated the time lag incident to the high pressure pump and confined the high pressure to within the die closing cylinder, allowing the use of low pressure piping and low pressure valves throughout the system, with the exception of the high pressure pilot operated check valve.

The die closing cylinder and its integrally built-in intensifier are the only special units in the system. All other hydraulic and pneumatic components, including valves are standard items.

The diagram, Figure 2, shows the general construction of the die closing cylinder and intensifier assembly. The hydraulic die closing cylinder is a conventional double acting type. Chevron or "V" piston packings effect a dead-tight seal for conserving the high pressure provided by the intensifier.

The intensifier, also double acting, has its piston fitted with automotive type piston rings. The piston rod of the intensifier cylinder functions as a plunger to intensify the pressure in the die closing cylinder and is sealed against such pressure by "V" rod packings. The blind head of the die closing cylinder and the piston rod head of the intensifier cylinder are common; a block of machined flame-cut steel functions as the center cover.

The oil flow from the pump and accumulator is directed to the blind head of the intensifier (after the die closing cylinder completes its approach stroke), the intensifier piston is forced forward, attempting to impact the plunger into the column of oil behind the piston of the die closing cylinder.

The ratio of the intensifier piston area to that of the piston rod plunger being approximately 9 to 1, the pressure generated by the intensifier plunger is theoretically line pressure multiplied by this ratio. Since the

(Continued on page 18)

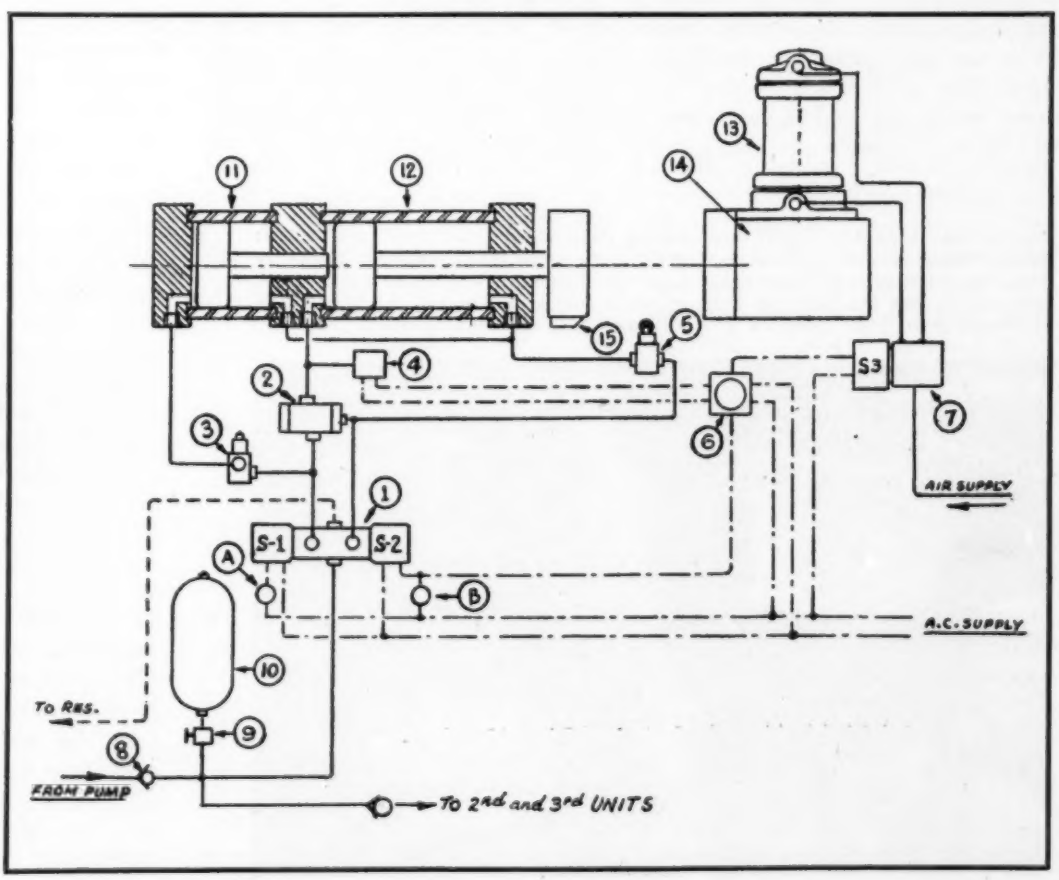

Fig. 2. The schematic arrangement of the general construction of the die closing cylinder and intensifier assembly and circuits to operate a four second cycle.

AIR-HYDRAULIC TEAMWORK in batching reclaimed rubber

Part II

The general layout of the batching system, the operation of the three air operated slide assemblies and the by-pass arrangement were described in part I; the operation of the unloading and loading hoists, the transfer section and the emergency stops are described. This system has saved over $100,000 in the preparation and distribution of rubber and compound batches.

By EARLAND E. HARVEY
Chief Engineer
U. S. Rubber Reclaiming Co., Inc.
Buffalo, New York

AT THE FEED END OF THE FIRST loading conveyor is an unloading hoist. Figure 7 shows the unloading hoist (right). The loading hoist is at the left behind the conveyor turn. The cams which operate the hoist valves are visible just under the chain. This hoist or elevator is a device for removing an empty container from the carriage and lowering it to the level of the load conveyor, which carries the container off the hoist. The unloading hoist is actuated by an empty load unit. The normal position of the unloading hoist is up to approximately 7/8 in of the full stroke of its hydraulic cylinder, where it is held by a hydraulic stop and check valve which cuts off the flow of oil to the hoist cylinder. The position of this point is controlled by presetting of the valve.

Figure 8 diagrams the hydraulic circuit of the unloading hoist.

As the empty load unit passes directly over the hoist center, the outward positioned roller on the carriage slide assembly contacts an overhead hydraulic valve. The valve causes the hoist to rise and carry the empty container with it, while the carriage goes on without it. At a short distance farther on the overhead travel, the roller contacts another valve which lowers the hoist to its extreme lowest point, where it remains until the load conveyor carries the empty container off the hoist. As the container leaves the hoist, it contacts a hydraulic valve which sends the hoist back up to its normal raised position, ready to receive another empty container.

As the empty container travels along the first load conveyor, it passes under the rubber loading stations, of which there are three. The position of the eye in the slot on

Fig. 7. The unloading (right) and loading (left, behind conveyor turn) hoists. Part of the stop and pusher equipment is at the floor level under the conveyor turn. The loading hoist is in the process of dropping away from a container, just raised, and the carriage has started to move on. The valve which raises the hoist to its "up" position is at the right, opposite the operator.

the container determines the loading station at which the container stops for its load. This eye contacts a hydraulic valve which operates a cylinder. The cylinder throws a stop against the container to hold it in position while the rubber is dumped in. This stop then opens the load box overhead, causing it to dump. The hydraulic cylinder which causes the weigh box to dump also actuates the valve which causes the load box cover to close and the stop to be removed. This frees the container which proceeds to the transfer section.

The Transfer Section

The transfer section is raised into a gravity position as the container contacts the lever of a hydraulic valve at the end of the first load conveyor. The containers move by gravity across the transfer section, aided by pushers. As the transfer section rises, it causes the container to contact an air valve, charging the pusher cylinders. The three pusher cylinders, shown in Figure 9, mounted horizontally, give the container a good shove down the gravity roller incline. This keeps the containers spaced out properly and overcomes the tendency of the gravity travel to slow down due to accumulations of oil and dirt. At the lower end of the transfer section, the container moves against the lever of an air valve which charges a cylinder, actuating a hydraulic valve, which, in turn, reverses the section hoist through a pilot operated hydraulic valve.

Figure 10 shows the three pusher cylinders, the hinged ball which operates the hydraulic valve behind it as an incoming container (lower left) seats on the lowered transfer section, and the air valve which operates the pusher cylinders.

Compounds are added and dumped while the containers are in motion. The automatic weighing stations were quite a problem. The final answer, which has worked out very satisfactorily, was achieved by means of electro-magnetic feeders controlled by photo-electric beams.

Before the system was started, the operator manually sets the weight of compound desired on the scale beam. As soon as the switch is turned on, material starts to flow from the storage bin. When the weight of the material nearly balances the weight

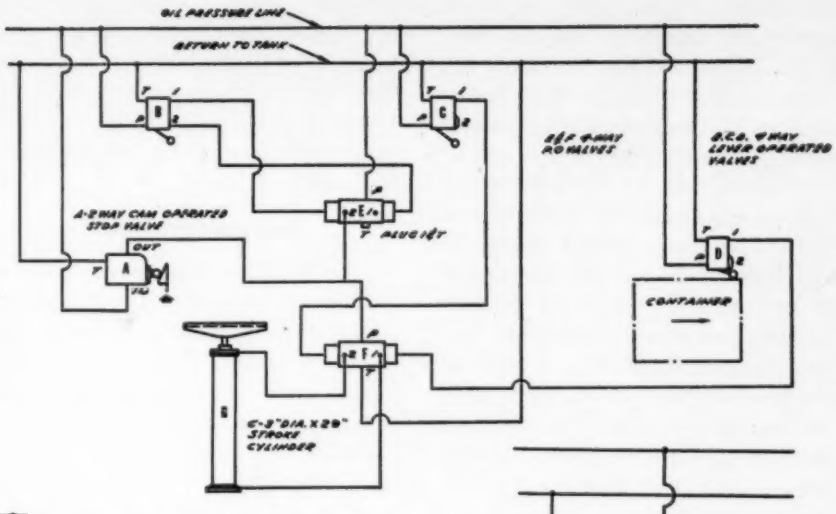

Fig. 8. The hydraulic circuit of the unloading hoist.

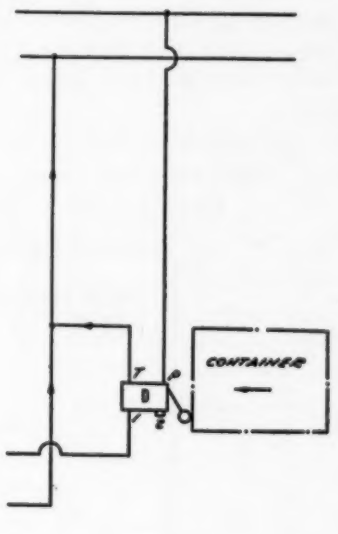

Fig. 11. Detail of valve D, four-way lever operated, in the loading circuit. The rest of the circuit is identical with Figure 8.

set on the scale beam, a target on the dial portion of the scale cuts the light beam. A series of relays cuts off the coarse fed and energizes the dribble feed. When the target reaches zero on the scale, its back edge passes through the light beam. This energizes another relay which cuts off the dribble feed. The weighed material is held until one of the compound tripping eyes turns the weigh bucket one quarter turn to dump. At this point another relay is energized which starts the coarse feed again. Compounds up to seven pounds can be weighed in a matter of 15 seconds. When more compounds are needed, two stations are put into use.

The entire hydraulic circuit is taken care of by two pumps or by one large stand-by pump. Pumps are are run continuously and by-pass one large stand-by pump. Pumps are run continuously and by-pass through a relief valve in the system piping when oil is not being used. The pumps are also fitted with integral relief valve for emergency bypassing. The integral relief valves are set at slightly higher pressures than the line valves. In approximately four years of operation the only service replacements have been parts of flexible couplings.

Loading Hoist

The reloaded container travels along the second load conveyor until the container strikes valve "D". See Figure 11. If there is no container on the hoist, a stop holds the next container back until the hoist cycle has been completed, at which time the stop is removed and a pusher cylinder kicks the held container ahead rapidly to make up lost time. The hoist comes up against valve "A", which is just high enough to get the container off the conveyor chain and permit fully loaded containers to get over it. The full loads are those which did not dump on their first trip around the circuit and are going over the hoist a second time.

When an empty carriage contacts valve "B", the loaded hoist rises to the full upward stroke and waits in front of the empty carriage. When valve "C" is contacted, the hoist

lowers and leaves the loaded container on the hooks. The hoist returns to extreme bottom of stroke until another loaded container comes along on the conveyor.

The machines being supplied by this system have no definite load cycle. The time required for batching depends on variable conditions of the material, such as moisture content and other workability factors. Another variable is the time or the speed of the men taking finished batches off the mills. The system is designed to furnish a uniform number of loads in a prescribed period, with a plus or minus taken care of by variable speed drives on all conveyors. No means has ever been devised to create a uniform demand on the system; for this reason there can be no definite pattern of supplying the loads.

Emergency Stops

The system is equipped with a number of emergency stops, situated about 40 feet apart all around the conveyor circuit. These were decided upon when the system was first started and before the unpredictable "bugs" were worked out. They were also intended as a personnel safety measure since a worker might be between a hopper and an approaching container. Double air valve safeties were also installed at each of the hoists. By anticipating a possible failure in a hydraulic valve when the hoist was up holding a load and another container was approaching on the conveyor, collisions were avoided. When the hoist is in the up position, the top of the container is in contact with an air valve, which is connected, in turn, to a second air valve in the path of the approaching load. When both air valves are compressed, air is admitted to an air cylinder which operates an emer-

(Continued on page 28)

Fig. 9. Circuit of pushers at the transfer section.

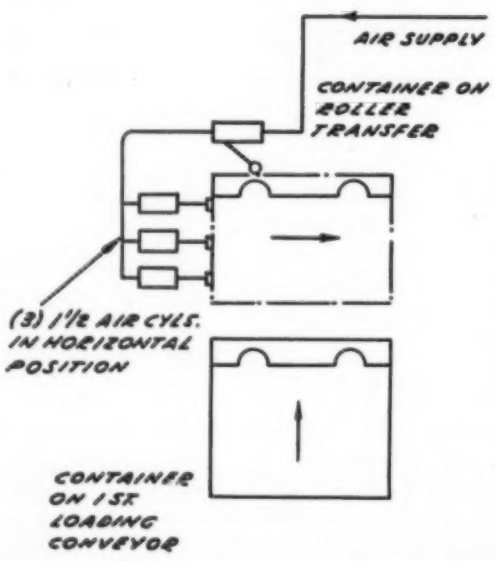

Fig. 12. Emergency stops at both hoists.

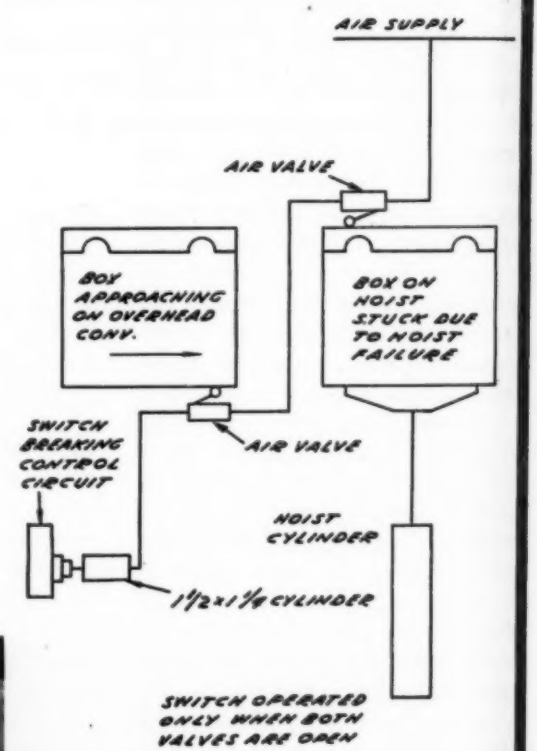

Fig. 10. The top or front end of the transfer section with a container started down the roller conveyor. The pusher cylinders are at the left. Behind the ball, suspended on an hinged strip, is a hydraulic valve; the movement of a container against the ball operates the valve causing the transfer section to raise. The pin and angle assembly on the side of the container, trip eyes and slots for carriage hooks are shown.

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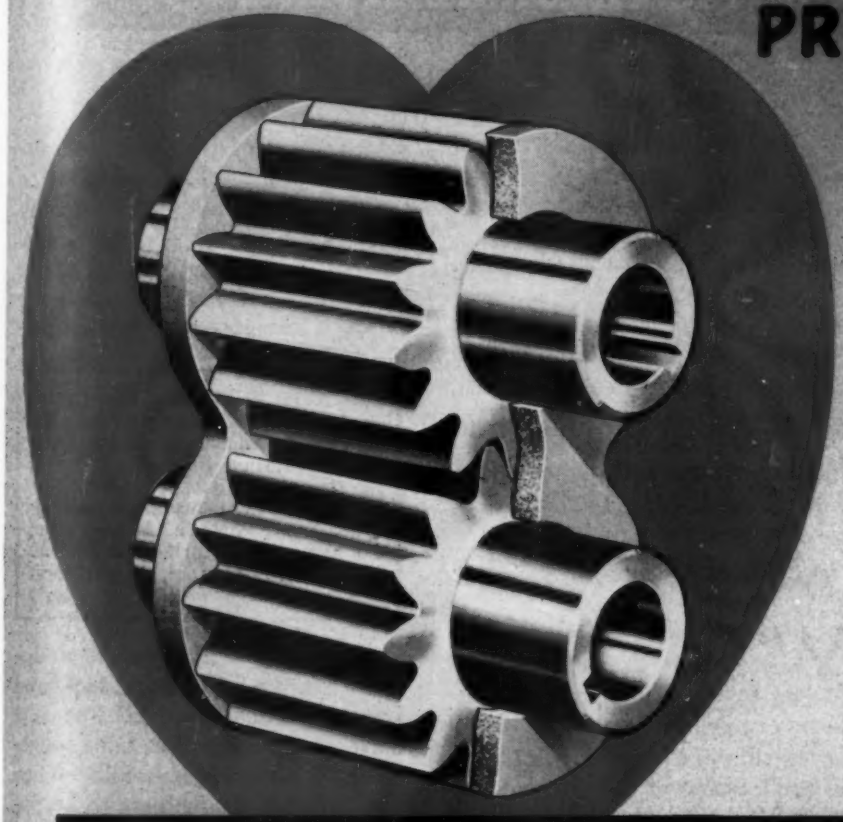

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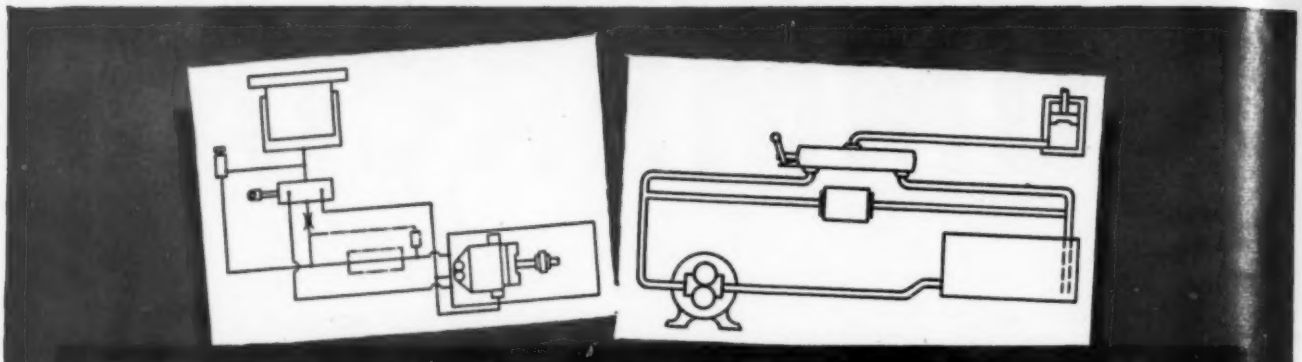

A Beginner's Course in Basic Hydraulics

Chapter II

LIQUID FLOW
Part 3

The measurement of flow factors—input head, static pressure head and velocity head—water hammer and the working elements of hydraulic systems are discussed.

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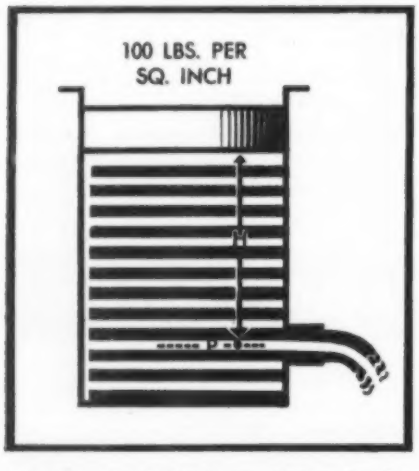


Fig. 31. Input head, as shown, is the gravity head plus the applied force. The input head measures the total potential energy available for hydraulic use.

Measurement of Flow Factors

WE ARE NOW IN A POSITION TO discuss measurement of the factors involved in flow. For purposes of comparison, they should all be stated in the same units, e.g., feet of head, inches of head, pounds per square inch, etc. Our discussion will be in terms of head rather than pressure, since head lends itself more easily to the use of illustrative diagrams when gravity is under consideration. Atmospheric pressure will be ignored in our examples, since it would balance out in the situations we shall consider.

Measurement of input head. Input head due to gravity is measured by the vertical distance from the surface of the liquid to some convenient horizontal reference line. When the liquid is also subject to an applied force, the head equivalent to this force must be added. Accordingly, in Figure 31, where the water in the tank is under a force yielding a pressure of 100 psi, the total input head at P is H plus 230.9 feet, since it would take a column of water 230.9 feet high to produce a pressure of 100 psi.

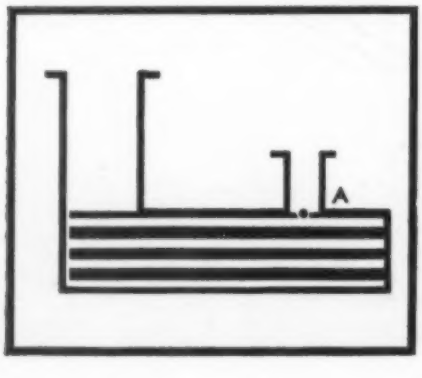


Fig. 32. Static pressure head. With the horizontal pipe just filled with liquid, the pressure at A is zero.

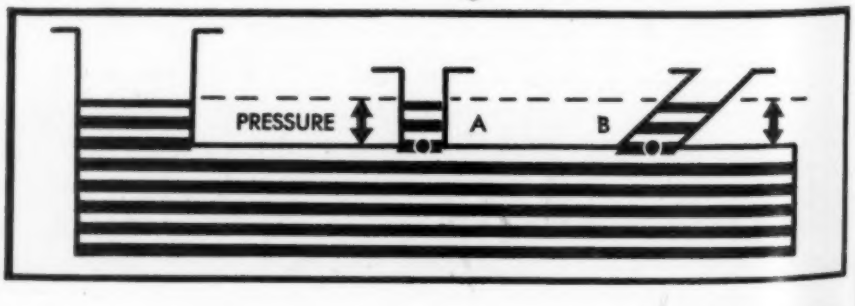


Fig. 33. With standing liquids, the same pressure level is obtained in tubes regardless of their size, shape or inclination from a common pipe.

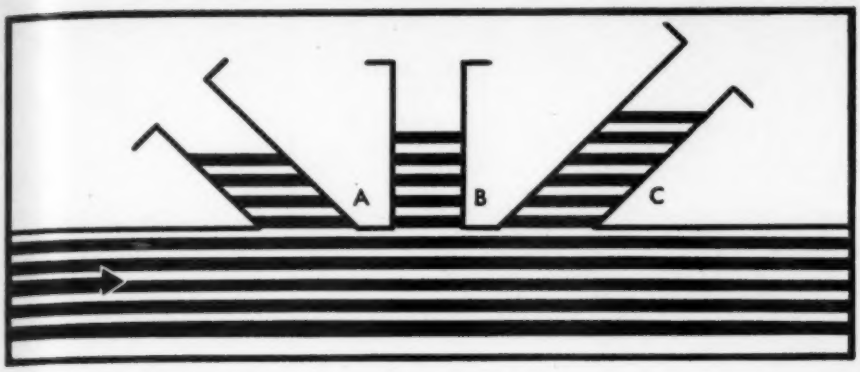


Fig. 34. With flowing liquids, the velocity head increases the level in a tube inclined in the direction of flow, C; decreases it inclined against the flow, A. Tube B is at right angles to the direction of flow.

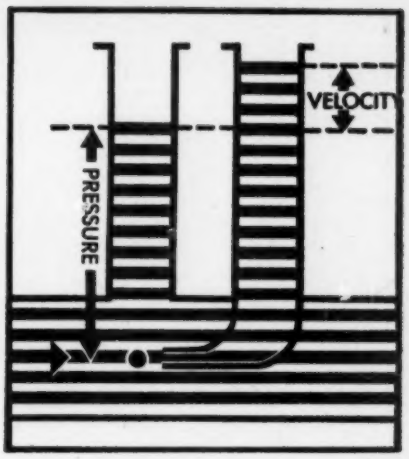


Fig. 35. A Pitot tube opening (right) inserted directly in the path of a liquid flow converts velocity head into equivalent static head. Turned to right angles to the flow, the liquid drops to the static head level; turned in the direction of flow, the liquid in the tube will be below the static pressure level by an amount approximately equal to the velocity head.

Input head measures the total potential energy available for hydraulic use. It can be measured between any two points in a system, as was done in Figure 31, or between any point in a system and a convenient reference level. In each case it measures the energy available to do work between the levels used.

Measurement of static pressure head. In Figure 32, liquid is standing so that it just fills a pipe. The pressure at A is obviously zero. If the level of standing liquid were as shown in Figure 33, pressure at A would be as shown. With standing liquids, the same pressure levels will be shown, no matter what the size, shape or inclination of the tube. Thus the tube at B shows the same pressure as the tube at A. With moving liquids, however, static pressure can be measured only by tube standing at right angles to the flow in the system.

If a measuring tube is inclined in the direction of flow, the level in the tube will stand too high; if it is inclined against the direction of flow, it will stand too low. This is shown schematically in Figure 34. The reason is that the velocity head, which acts in one direction only, tends to add to the pressure head at C and to subtract from it at A. The tubes must be flush with inner surface of the pipe and smoothly joined to it, to minimize friction.

Measurement of velocity head. If we know the rate of volume flow of a liquid and the area of cross section of the pipe at a given point, the velocity of flow at that point is equal to the first figure divided by the second. Velocity can then be stated as velocity head by remembering that head varies as the square of velocity. The numerical values can be determined by the formula:

$$\text{Head in feet} = \frac{(\text{velocity in feet per second})^2}{64.3}$$

For example, if water is flowing at the rate of 300 cubic feet per minute, and the area of cross section of the pipe at a certain point is 0.4 square foot, the velocity at that point will be 300/0.4 or 750 feet per minute or 12.5 feet per second. Using the formula, the velocity head in feet will be:

$$\frac{12.5^2}{64.3} = 2.44 \text{ feet}$$

Velocity head can be directly measured at any point in a pipe by inserting a Pitot tube into the pipe at the point desired (Figure 35). The Pitot tube is a small tube open at both ends and curved at the bottom to minimize friction when the tube is inserted into a moving liquid. The opening of the tube is inserted directly in the line of flow so that the liquid running into it has its velocity head converted into the equivalent static head. The tube also measures the static pressure prevailing in the liquid, which must be subtracted to give the velocity head. Static pressure can be obtained by another tube inserted at right angles to the direction of flow.

If the Pitot tube is turned so that the opening is at right angles to the flow, the liquid in the tube will drop to the static pressure head level. If the opening is placed directly opposite to the line of flow, the liquid in the tube will stand below the static pressure level by an amount approxi-

Fig. 36. Friction head is shown as the difference in static pressure heads at 1 and 2, assuming the same velocity at both points.

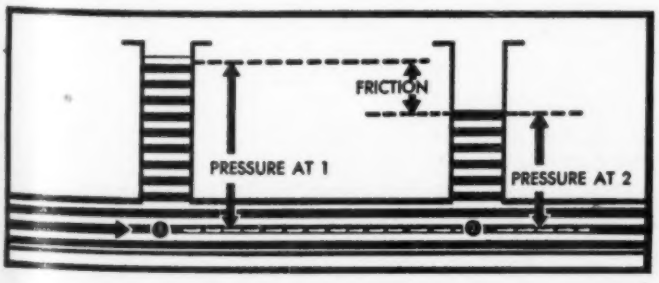
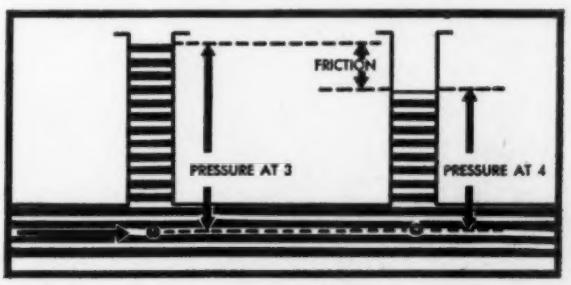


Fig. 37. With increased static pressure, the friction head is constant, i.e., the total static head, neglecting friction, has no effect on the friction head.



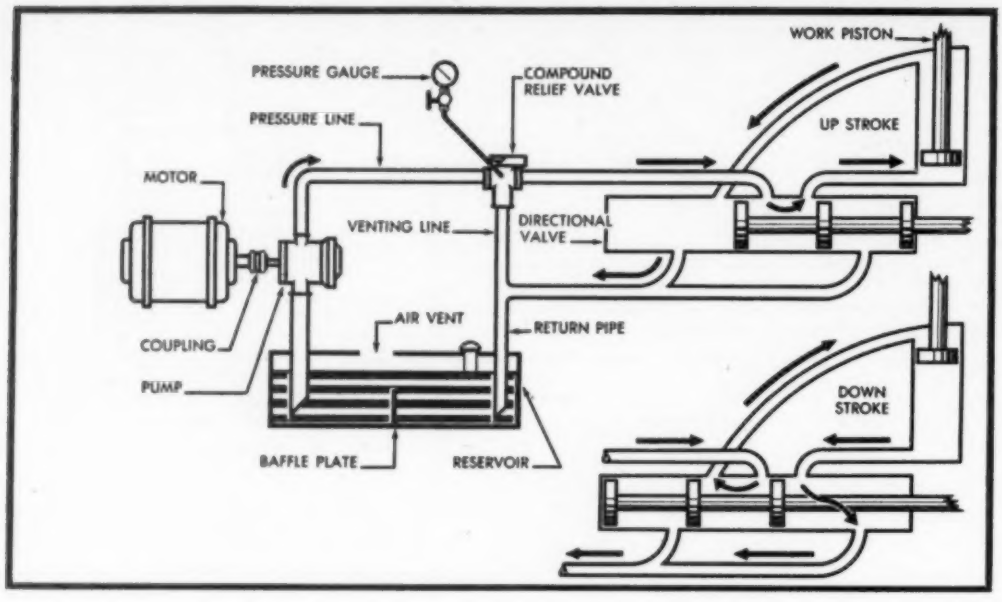


Fig. 38. A typical schematic diagram. All of the "indispensable" parts of a working hydraulic system—motor, pump, transmission lines, reservoir, cylinder and piston, valves and gauges—are included.

mately equal to the velocity head.

Measurement of friction head. In Figure 36, the static pressure heads at 1 and 2 are as shown. The friction head between 1 and 2 is therefore the difference, assuming that the velocity at both points is the same.

Although the friction head between 1 and 2 was measured in terms of static pressure, the magnitude of the total static head, apart from friction, will have no effect whatever on the friction head. Thus in Figure 37, where the liquid in the pipe is under a considerably greater static pressure, the friction head between the two points remains unchanged for the same pipe, liquid and velocity.

Water Hammer

When flow in a pipe is interrupted too quickly, as for example by the hasty closing of a valve, the onward motion of the liquid is suddenly halted. The inertia of the liquid causes a sudden high pressure, the effect of which is like a hammer blow. This sets up a pressure wave, moving at about a mile per second, surging back and forth through the system, alternately stretching and compressing the pipe. This can put a system under great strain; the condition is accompanied by clanking sounds.

The pressure generated by water hammer is over and above the ordinary pressure of the system, since it comes from the practically complete and very sudden stoppage of the liquid flow in the system. Care should be taken not to induce water hammer, since it may rupture the system or damage connections. Conditions leading to chronic water hammer should be investigated and remedied, as for example, by the installation of slower-acting valves or pipe of larger diameter near the valves. The addition of an air chamber just ahead of a valve subject to this condition will help absorb the pressure waves accompanying closure of the valve.

Elements of Working Hydraulic Systems

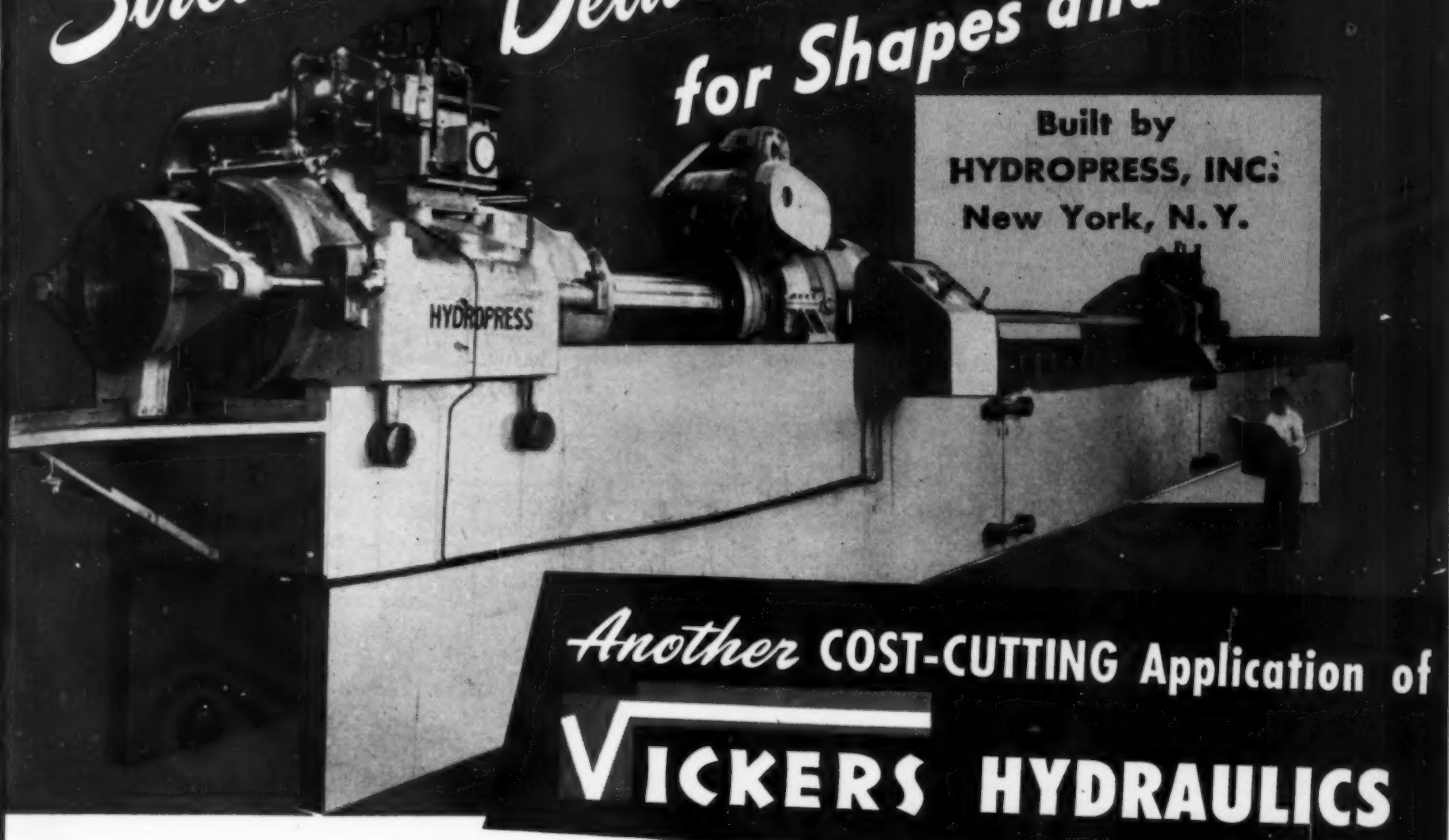
Indispensable parts of a working system. So far we have discussed hydraulic systems in rather general terms. We have not, for example, considered the special qualities of the different liquids that might be used, nor the different types of pipes and fittings that might be used to carry the liquid, nor have we accounted for the force applied. Under actual working conditions a pump is required to drive the working parts of the system. A source of energy, e.g., steam power or an electric motor, is also needed to run the pump. The energy supplied to the liquid through the pump must be transmitted through pipes to a work cylinder and piston, or the equivalent, and the piston must be mechanically linked to the actual work operation, where some resistance will be overcome. In addition, a reservoir is needed from which liquid can be pumped when necessary, and to which liquid can be returned when the system must be relieved. Finally, valves are required to direct and control the flow of liquid, and gauges to measure the pressure at different points.

Schematic diagrams. Many arrangements of the different parts of a hydraulic system are possible; an actual illustration of even a simple system might be quite complicated. The working relations of the parts of a system to each other can be indicated, however, by a *schematic diagram,* without any effort to indicate in detail how each part works, exactly where it is located, or what its actual size is. From the study of a schematic diagram, it is possible to see how the system as a whole is organized. Figure 38 is an example of a schematic diagram. Even simpler diagrams, with transmission lines shown as single lines and components by conventional symbols, are becoming more and more common.

Complicated hydraulic systems obey all the laws of hydraulics just as rigorously as do the simplest devices. In the chapters that follow, the student should take the trouble to test each new situation as it arises in the light of the fundamental hydraulic principles.

Review questions for Chapter 11 are to be found on page 28. ***The September installment will begin a study of pressure gauges and volume meters. Save each installment for reference.***

Stretch-Straightening-Detwisting Machine for Shapes and Sections



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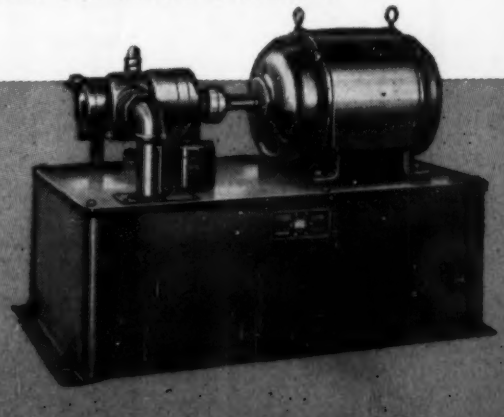


Combination Air-Oil Circuits

By W. J. SCHUPNER
Design Engineer
Chicago, Illinois

THE PROBLEM OF WHETHER TO USE air or oil as a medium for control circuits has been fairly well defined for most industrial applications. As a general rule, air is used where requirements are such that pressure is low, speed of operation is fast and uniform velocity is not important. Variations in the length of stroke of an air cylinder are difficult to control within close limits by the use of valves because of the compressive nature of air and differences in friction factors of packings. The initial cost of an air installation as compared to oil is usually much lower. Conversely, hydraulic circuits are adapted to high pressure, speed is relatively slow and may be varied infinitely over the range of the pump delivery, while changes in length of cylinder stroke may be held within very close limits.

However, there are many instances where the use of these mediums in combination result in great advantage over the exclusive use of one or the other. Illustrated here are three schematic circuits of commonly used adaptations of this practice.

Figure 1 shows a large vertical type hydraulic press in which the ram moves down to meet the work under the force of gravity. After contact, the work is completed and the ram returned. The capacity of the pump is sufficient only to sustain the necessary working pressure and delivery enough oil for desired return speed of the ram. It is apparent, therefore, that during the rapid down stroke of the ram the displacement of the pump is inadequate to completely fill the press cylinder and cavitation would occur unless additional oil was drawn or forced into it from some secondary source. If the oil used is thin and the valves from this source are of large size, atmospheric pressure would suffice for this purpose. However, the oil commonly used in a large press of this type is rather thick and in order to maintain proper velocity and pre-

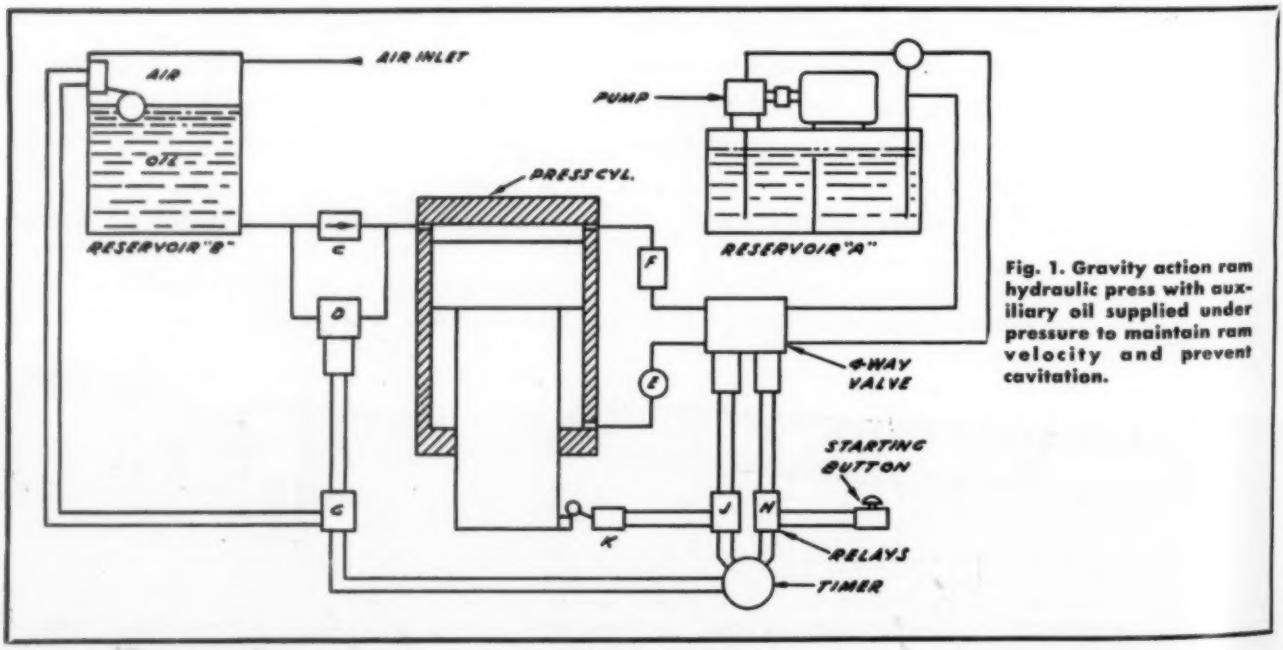


Fig. 1. Gravity action ram hydraulic press with auxiliary oil supplied under pressure to maintain ram velocity and prevent cavitation.

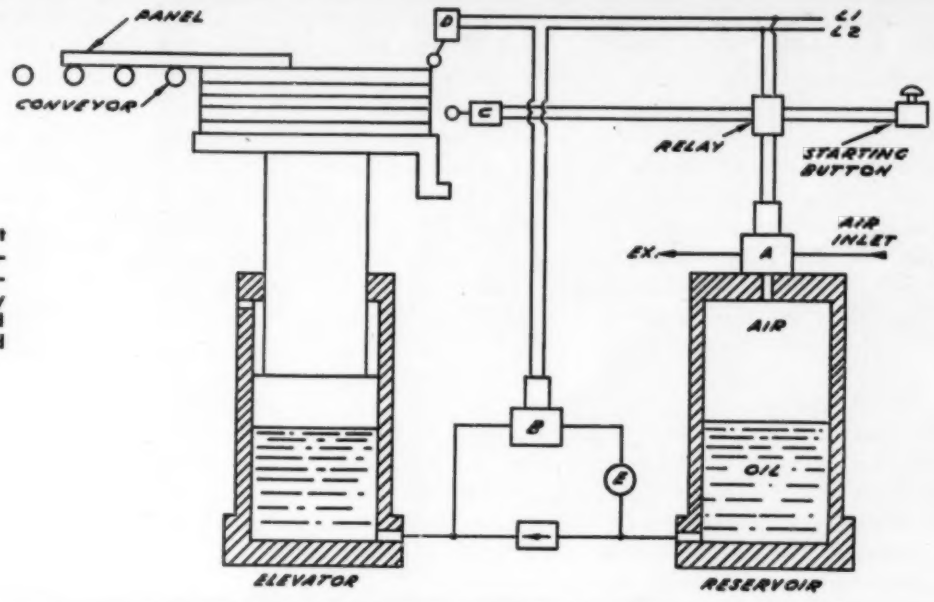


Fig. 2. In this circuit which operates a constant level loading elevator air is the primary power source, oil is used to control the downward ram movement.

vent cavitation, air at low pressure is admitted to the top of the secondary reservoir "B", thus assuring correct performance of the unit.

Operation of the circuit is as follows: The ram, which is held upward by oil trapped under the piston, is directed down by pressing the starting button, closing relay "H" and starting the timer. The open center spring-centered, four-way solenoid hydraulic valve shifts and the ram descends at a rate governed by speed control valve "E". The full capacity of the pump from reservoir "A" is directed to the top of the cylinder and additional oil under air pressure is admitted from reservoir "B" through check valve "C". The work stroke is completed by high pressure from the pump; oil to reservoir "B" being trapped by check valve "C" and normally closed, two-way solenoid valve "D". At the end of the time cycle, the timer opens relay "H" and closes relay "J", reversing four-way directional valve and closing relay "J" which opens valve "D".

Return oil now goes back to reservoir "B". In order to maintain a volume balance between reservoirs "A" and "B", a relief valve "F", which contains a by-pass check, is placed between the cylinder and the four-way valve. The relief valve is adjusted to a pressure slightly higher than the air in "B". A float switch in "B" breaks the holding circuit in relay "G", closing two-way valve "D"; the remainder of oil in the cylinder passes through valve "F" to reservoir "A".

At the top of its stroke, the press ram contacts limit switch "K", opening relay "J" which centers the four-way valve, permitting oil from the pump to return to the reservoir.

Circuit for Constant Level Loading Elevator

Figure 2 illustrates a constant level loading elevator which receives plywood panels from a fixed conveyor. Each time a panel is delivered the elevator is automatically lowered a distance equal to the thickness of the panel. In this case, air is the primary

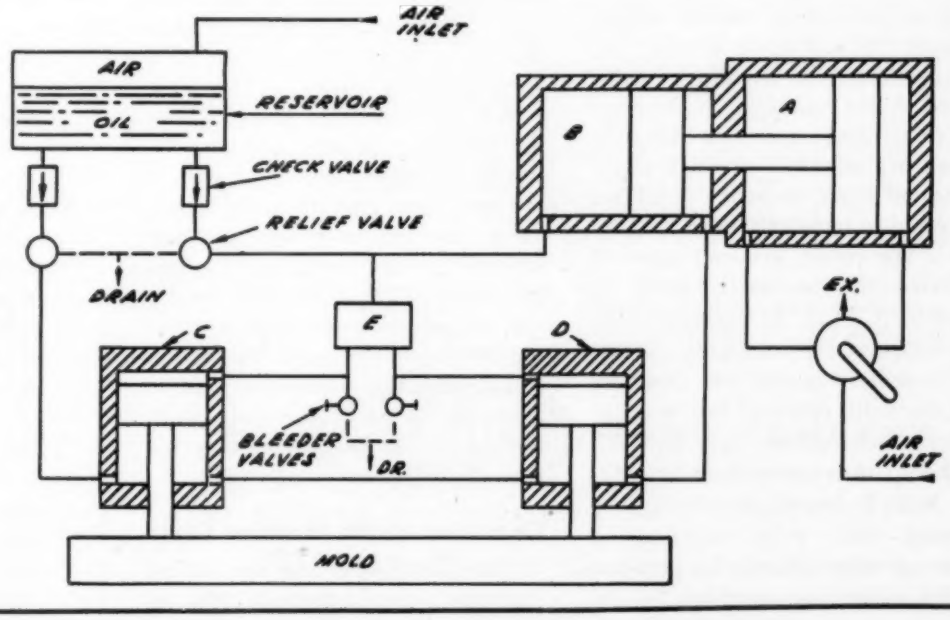


Fig. 3. An air-oil tandem cylinder arrangement and equalizing valve for synchronizing oil flow to a pair of cylinders to close a foundry mold. Power is derived from air, oil is the control medium.

source of power and raises the empty platform to the loading position. It descends by gravity; oil is used to control the downward movement.

The unit works in the following manner: To raise, the elevator operator presses the starting button to close the relay which energizes the solenoid on the three-way spring return air valve "A". Air is directed to the top of the reservoir and forces oil through the check valve to the oil cylinder. This raises the elevator to the level of the conveyor. As the elevator reaches the level of the conveyor, it contacts limit switch "C", breaking the relay holding circuit and exhausting air from above the oil in the reservoir. Oil under the elevator piston is now trapped by the check valve and normally closed two-way solenoid valve "B".

A panel moving from the conveyor onto the platform contacts normally open limit switch "D" which opens valve "B", permitting oil to return to the reservoir at a rate determined by speed control valve "E". After the roller of limit switch "D" has slipped off the edge of the panel, valve "B" closes and the elevator comes to rest.

This procedure may be reversed, so that instead of having the elevator descend to load, it can be made to ascend to unload by reversing the action of the valves and limit switches.

Air and Oil Cylinders in Tandem

Figure 3 shows schematically a method whereby two cylinders which close a foundry mold were synchronized. Power is derived from air and oil is the controlling medium. An air cylinder "A" and an oil cylinder "B" are connected in tandem as illustrated. A line running from the head end of "B" has a gear type hydraulic equalizing valve "E" through which measured equal amounts of oil are delivered to mold cylinders "C" and "D". The piston and rod areas of cylinder "B" is exactly equal to those of "C" and "D" combined, but the stroke of "B" is slightly longer.

The mold is opened and closed by the manually operated four-way air valve which controls cylinder "A". Make-up oil to compensate for packing leaks is forced into the system through check valves from an oil reservoir which is under air pressure. Relief valves are provided to discharge surplus oil which may accumulate on one side of the pistons as a result of small variations in diameter dimensions. The hydraulic equalizing valve is claimed to divide the flow equally within an accuracy of one-half of one percent.

The bleeder valves at the top of cylinders "C" and "D" aid in setting up the initial installation and serve to make slight adjustments in synchronization which may be necessary after the unit has been in service over a period of time. A method has been worked out employing hydraulic valving by which the synchronized cylinders will level or square themselves automatically by means of a servomechanism where extreme accuracy is required.

FOUR SECOND CYCLING

(Continued from page 7)

line pressure is approximately 500 psi, the indicated yield of high pressure is approximately 4500 psi. Deducting accumulator pressure drop and system friction, the actual minimum intensified pressure is around 4000 psi.

Because hydraulic oil is practically non-compressible, the intensifier plunger is not deeply forced into the oil in the die closing cylinder. With the 40 gpm pump flow augmented by fast accumulator action behind the intensifier piston, the pressure within the die closing cylinder is intensified to the required 4000 psi almost instantaneously—actually the high pressure is generated in approximately one-tenth second—confining this pressure within the die closing cylinder and the pilot operated check valve.

With pressure tight seals on both the intensifier plunger and the die closing cylinder piston and with a pressure-tight pilot operated check valve, the localized high pressure does not quickly dissipate. However, the stroke of the intensifier cylinder was made sufficiently long to meet the contingency of some leakage, in which case the intensifier plunger continues to move forward, maintaining the required pressure during the very brief clamping period.

Operation of the Machine Cycle

The operation of the die casting machines is semi-automatic. The sequence of operation may be followed by reference to the diagram:

1. (a) To start the cycle, operator momentarily depressed pushbutton A, energizing solenoid S-1 of the master four-way valve 1 to direct oil flow to the blind end of the die closing cylinder 12 through pilot operated check valve 2.
   (b) Die closing cylinder traverses forward at fast approach speed.
   (c) Cam 15 contacts cam roller of flow control or deceleration valve 5, slowing die movement at end of stroke to prevent impact damage of dies.
   (d) Pilot operated check valve closes (at end of the cylinder stroke).
2. (a) Sequence valve 3 opens at pre-determined pressure setting, after full closure of dies, and pump flow is directed to blind end of intensifier 11.
   (b) Intensifier piston and plunger move forward to intensify oil trapped behind die closing cylinder piston.
3. (a) At a pre-determined high pressure setting, hydraulic pressure switch 4 functions to energize and start electric timer 6, which times balance of sequences. This arrangement provides a safe interlock as the injection shot of molten metal cannot be made until the safe die clamping pressure has been effected.
4. (a) As timer starts, solenoid S-3 of four-way air valve 7 is simultaneously energized, directing air pressure to the blind end of air (shot) cylinder 13.
   (b) Shot cylinder plunger moves down, projecting charge of molten metal into the closed dies.
5. Dwell period; die closing cylinder, intensifier and shot cylinder are under full pressure during this period.
6. (a) Electric timer times out, de-energizing solenoid S-3 of air valve 7 and energizes solenoid S-2 of master valve 1.
   (b) De-energizing solenoid S-3 reverses air valve 7, returning shot cylinder plunger to original retracted position.
   (c) Energizing solenoid S-2 of master valve 1 reverses this

valve to return die closing cylinder to its retracted position; oil flow to the piston rod end of die closing cylinder passes freely through built-in check valve in deceleration valve 5.

7. As master valve 1 reverses, oil pressure is applied to the pilot port of pilot operated check valve 2, opening this valve and permitting oil behind die closing piston to return to the reservoir through master valve 1.
8. (a) The die closing cylinder and the intensifier plunger retract to their original positions. (b) Oil behind the intensifier piston is returned to master valve 1 and thence to the reservoir through the built-in check valve in sequence valve 3.
9. Die cast work piece is ejected automatically, or manually by operator, thus completing the cycle.

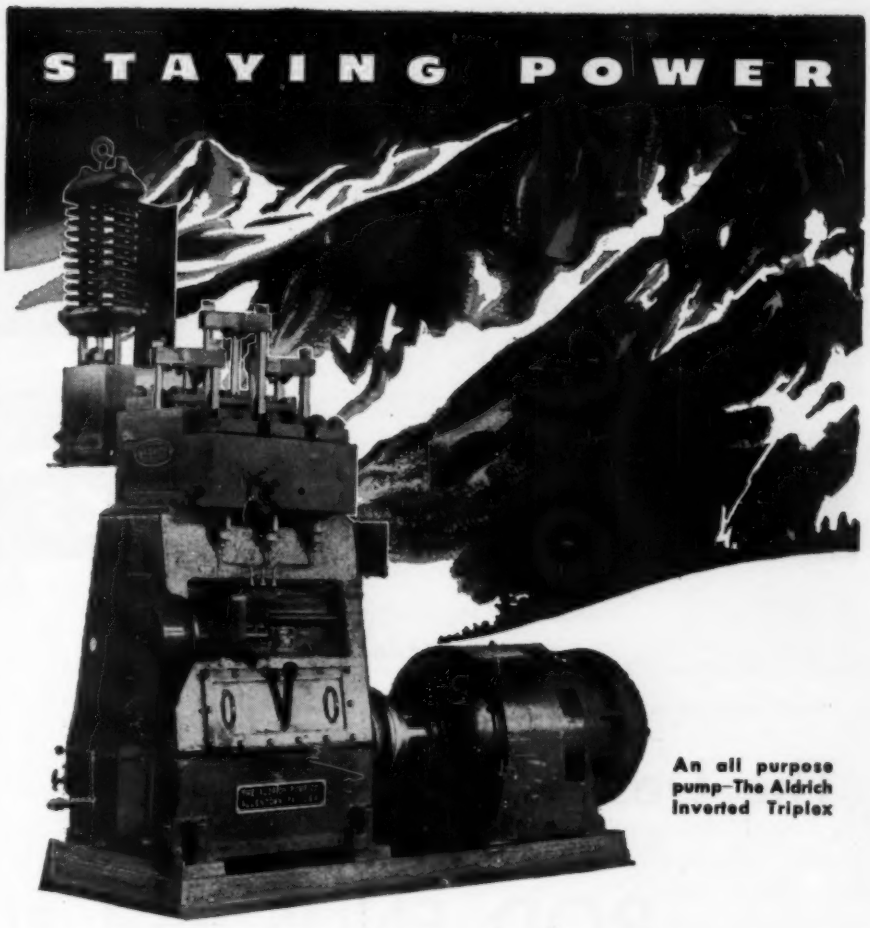
A second pushbutton, B, is incorporated in the electrical circuit as an emergency safety control. When this button is momentarily depressed, the master four-way valve is reversed and all cylinders return to their retracted positions.

A further safety feature, not shown on the diagram, is a normally open micro switch, wired in series with the pressure switch. In the event that any obstruction prevents the dies from completely closing, the micro switch remains open, preventing the pressure switch from actuating the timer and automatically stopping the cycle.

The resulting performance has been entirely satisfactory with production in excess of original calculations. Rates as high as 1200 shots per hour, and at one time 1400 shots per hour, have been timed. Maintenance over a period of approximately one year has been negligible and in spite of the excessively fast speeds, the indicated life of the components is well within expectations.

Coming in September

An outstanding article, *"Control of Hydraulic Fluids in Industrial Applications"*, by R. F. McKibben, Lubrication Laboratory, National Cash Register Company. The Aviation Section will carry a specially prepared article on *"Qualification Testing of Fluid Control Valves for Aircraft Systems"* by Frank P. McCord.



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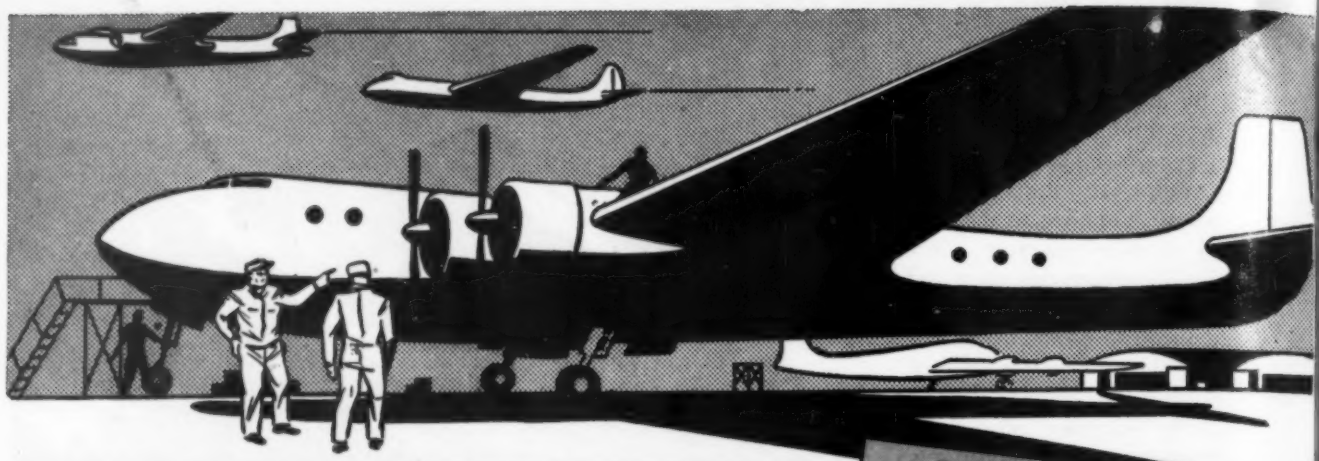


AVIATION HYDRAULICS

DESIGN
OPERATION
MAINTENANCE

FRED O. HOSTERMAN
Advisory Editor

The Design of ROD ENDS and FITTINGS for Actuating Cylinders

By MITCHELL H. WEISMAN
North American Aviation, Inc.

Introduction

THE MILITARY SERVICES GENERally require that each new design of hydraulic actuating cylinder for aircraft use must pass a number of qualification tests including a life-cycle test. For most actuating cylinders except surface control boost cylinders the minimum required life is 20,000 cycles of operation at maximum service operating load with full stroke each cycle. Surface control boost cylinders must withstand an additional 80,000 cycles of operation at one-half the maximum service operating load and one-half of full stroke each cycle. The cylinders must pass the above life-cycle test without failure of any component, including the attaching fittings. For this reason, hydraulic actuating cylinders and their attaching fittings must be designed with adequate fatigue strength as well as adequate static strength.

By combining methods of stress analysis with the results of experience, aircraft manufacturers have developed standardized practices for designing such parts of hydraulic cylinders as the heads, barrels, pistons and piston rods. However, some of the problems involved in the design of the attaching fittings, such as rod ends, bearings and attaching bolts, have not been clearly understood.

This article will discuss the problems of designing to prevent fatigue failure during cycle tests and in service.

Preliminary Considerations

The design of hydraulic cylinder attaching fittings is controlled by a number of physical limitations, such as size, shape of mating parts, and the requirements for installation and lubrication. In addition, each part should be designed so that it may be replaced with the minimum disassembly of other parts of the installation.

Size

The rod end, attaching bolt and other fittings must be designed to fit into a limited space, the dimensions of which have been determined by the design of the mating fittings and the interference of nearby parts.

Within this space, the parts must have adequate strength, permit such movement as may be required and provide access for lubrication. Finally, the weight of the parts must be kept as low as possible.

Shape

Rod ends may be either the single-eye type shown in Figure 1(a), or the clevis type shown in Figure 1(b). The screw thread by which the rod is connected to the piston rod may be either an external (male) thread or an internal (female) thread. The bearing through which the attaching bolt fits may be either fixed or of the self-aligning type.

Several considerations enter into the choice of the type of thread. Most actuating cylinder rod ends have male threads; primarily because most piston rods are hollow and a female thread can be tapped into the inside diameter of the rod. Then, too, a rod end designed with a male thread requires less space and usually weighs less than a correspondingly strong rod end with a female thread.

The choice between a fixed bushing and self-aligning bearing depends on the requirements of the installation. Where any misalignment is possible, either because of deflection of the structure during fabrication or in service, a self-aligning bearing must be used.

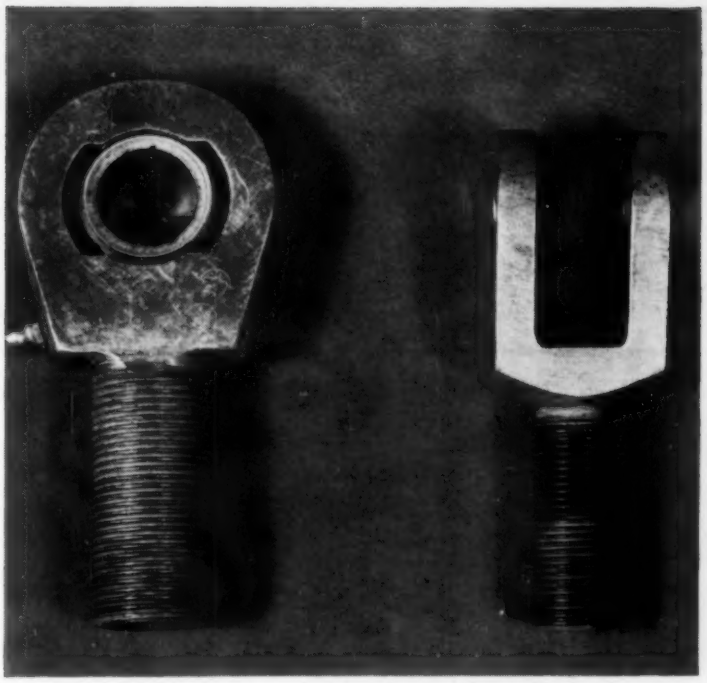


Fig. 1. Examples of single-eye type (left) and clevis type (right) rod ends.

Design

Once the general considerations of size and shape have been decided, the detail design of the parts can be started.

Attaching Bolts

Attaching bolts must be sufficiently long so that the grip portion will extend through the assembly and leave none of the threads in bearing. The diameter (d) of the bolt is determined by the cylinder design load (N) and by the length of free span (b) through which the bolt is subject to bending (Figure 2). Where the free span is long in relation to the diameter of the bolt, repeated loading may cause fatigue failure of the bolt due to induced bending stresses. The dimensions given in Table I for diameter of bolt *versus* free span length provide for adequate fatigue life at the indicated loads without entailing too great a weight penalty. These values are based on a theoretical analysis modified to match empirical results obtained from laboratory tests.

The grip portion of the bolt should have a smooth ground finish since it will serve as a bearing surface in most installations. Notches or grooves on the surface of the grip length should be avoided since they create stress concentrations and lower the fatigue strength of the bolt.

Bearings

Both anti-friction (ball and roller type) and plain (bushing type) bearings are used in attachments for aircraft hydraulic cylinders. For heavily loaded applications, however, anti-friction bearings impose a size and weight penalty when compared to plain bearings of comparable strength.

There are available a number of

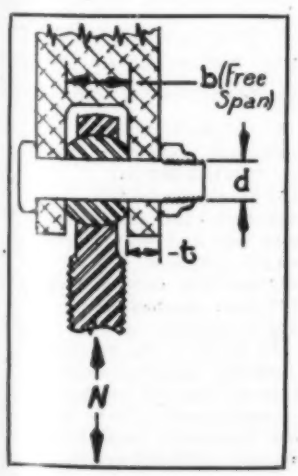


Fig. 2. Sketch of a typical rod end and attaching bolt installation.

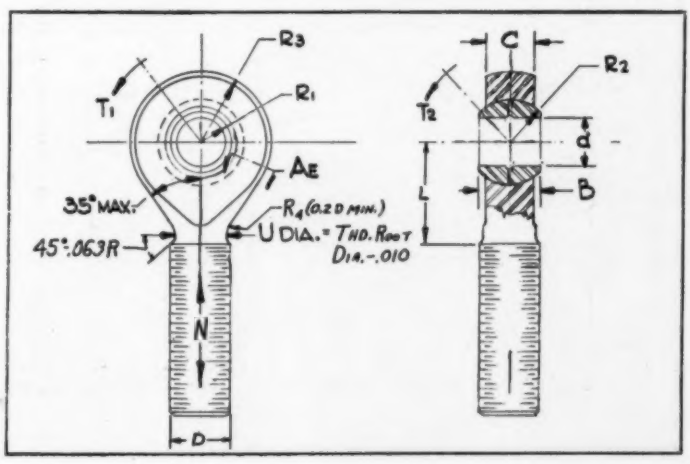


Fig. 3. Design dimensions for a single-eye type rod end.

Table I

Allowable Loads For Attaching Bolts For Hydraulic Actuating Cylinders

DIAMETER OF BOLT (d)	FREE SPAN (b)				
	⅜	½	¾	1	1¼
¼	1,500	1,250	885	700	.....
½	9,300	7,900	6,000	4,900	4,130
¾	.....	22,180	17,700	14,750	12,600
1	.....	45,200	37,100	31,500	27,400
1¼	.....	.....	65,000	56,000	49,200

Values given in Table are in pounds and are to be compared directly with the operating load.

standard commercial bearings, both fixed and self-aligning types, which have been approved for aircraft use. Nevertheless, in some cases where the design loads are high and the permissible bearing width is small, special bearings must be designed. The author has found the combination of an aluminum bronze journal and a chromium-plated steel bolt to be the most satisfactory, considering friction and the tendency to gall under conditions of insufficient lubrication. If greater strength is required, then steel bearings must be used; although there is more tendency to gall with steel bearings moving against a steel bolt, whether or not the bolt is plated.

Rod Ends

At this stage of the design a number of the basic dimensions of the rod end have been established. The various dimensions of single-eye type rod ends are shown in Figure 3. The width (C) of the eye of the rod end is limited by the distance (B) between the lugs of mating clevis and by the degree of misalignment required. The diameter of the hole through the eye (represented by R_2) is fixed by the size of the bearing. The distance (L) from the center of the bearing to the end of the threaded shank is determined by the installation requirements. The items left to be determined are the thread size (D), outside diameter of the eye (R_3) and the material.

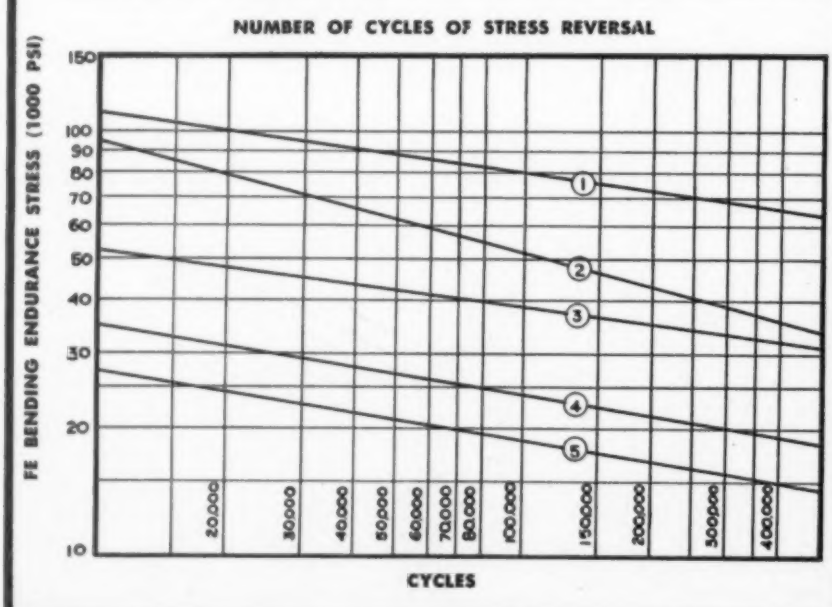
The choice of material in aircraft design is usually between steel and the high-strength aluminum alloys. In order to assure the required life expectancy the design must be based on the fatigue allowable strength rather than the static allowable strength of the material. The design allowable fatigue strength for steel and for the high-strength aluminum alloys are shown by the S-N curves in Figure 4.

Notch sensitivity is another important consideration in the choice of material for highly stressed rod ends subject to repeated loading. It should be noted that the notched fatigue strength of steel is at least three times the notched fatigue strength of the high-strength aluminum alloys, while the weight of steel is slightly less than three times the weight of the aluminum alloys. Therefore, many parts can be designed to have greater fatigue strength when made from steel than when made from an aluminum alloy without imposing any weight penalty.

The thread size (D) for the shank of the rod end is calculated by dividing the fatigue allowable strength by the design load to obtain the minimum root area. The smallest National Fine Series thread having the required root area is selected. A thread relief (U) should be provided at the end of the threaded portion of the shank to relieve the stress concentration at the root of the last thread. The design for the thread relief is shown in Figure 3. To provide to greatest fatigue strength the surface of the thread relief should have a finely ground or polished finish, and may be shot peened or cold rolled if desired.

In the design of the eye of the rod end and of the transition from the threaded shank to the eye, it is necessary to consider another stress besides that due to the cylinder design load. This additional stress is induced by the torque moment due to bearing friction, and results from the relative movement of the rod end about the attaching bolt as the

Fig. 4. Fatigue strength (S-N) curves for steel and aluminum (4130 steel, 24ST and 75ST aluminum alloys).



KEY

1. 4130 steel, smooth polished, H.T. 125-140,000 psi
2. 4130 steel, notched
3. 24ST and 75ST aluminum alloy bar and extrusion, smooth polished
4. 24ST bar and extrusion and 75ST bar, notched
5. 75ST extrusion, notched.

Note: All parts to be designed to notched specimen curve, except piston rods which may be considered smooth polished. Hydraulic parts to be designed to 20,000 cycles.

Table II

Comparison Of Weight And Fatigue Strength Of Steel And The High-Strength Aluminum Alloys

MATERIAL	WEIGHT, lb per cu in	STATIC TENSILE STRENGTH, psi		ENDURANCE STRENGTH, psi (Rotating Beam Data)					
				SMOOTH SPECIMENS			NOTCHED SPECIMENS		
		ULTIMATE	YIELD	10^4	10^6	10^8	10^4	10^6	10^8
4130 Steel	0.28	140,000	120,000	109,000	64,000	64,000	94,000	33,000	33,000
75S-T6[a]	0.10	80,000	70,000	57,000	25,000	21,000	26,000	13,000	7,000
Percent of Steel	36	57	58	52	39	33	28	39	21
24S-T4[a]	0.10	74,000	54,000	49,000	29,000	19,000	34,000	16,000	8,000
Percent of Steel	36	53	45	45	45	30	36	48	24

(a) Extruded shapes, mill heat treat.

piston rod extends or retracts during operation of the cylinder. The stress due to the torque moment can be calculated for plain bearings by the equation:

$$S_T = \frac{T\,c}{I}$$

where, S_T = stress due to torque moment (T), psi.
T = torque moment, in.-lb.
c = distance from neutral axis of section to extreme fiber
I = moment of inertia of section about its neutral axis

The torque moment (T) can be calculated by the equation:

$$T = uRN$$

where, u = coefficient of friction
R = radius from axis of rotation to bearing surface
N = normal load (cylinder design load)

The coefficient of friction, as determined by test, may vary from about 0.1 to 0.4 depending on the bearing materials and the effectiveness of the lubrication.

The Problem of Fatigue Failure

The need to design hydraulic cylinder attachments for adequate fatigue life has been mentioned briefly in the preceding sections. A complete discussion of the nature of fatigue failure is beyond the scope of this article, but the following explanation will serve to acquaint the reader with the essential features of the problem.

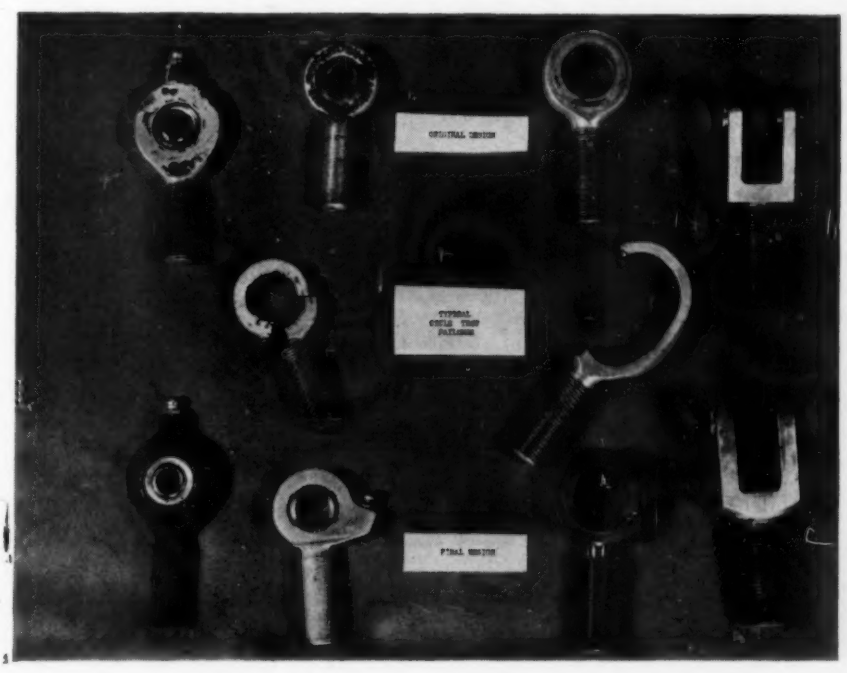
It is well established that a metal part will fail after a number of applications of a load much less than the ultimate tensile strength of the material. The failure is a progressive fracture; starting from a nucleus, usually at the surface, and progressing farther across the part each time the load is repeated. Eventually, as the unbroken section becomes smaller and the stress concentration at the end of the crack becomes greater, a point is reached where the next application of load causes the stress in the remaining section to exceed the ultimate strength of the material and fracture takes place.

The fracture appears to be of a brittle nature even in otherwise ductile materials. The initial portion of the fracture has a smooth appearance where the broken faces rubbed against each other as the crack progressed. The appearance of the last section to fracture is similar to that obtained in a notched-bar tensile test. The fracture shows the cleavage planes of the crystals of the metal giving the area a shiny crystalline look. For this reason the early investigators thought the metal had "crystallized" to produce the failure. Today this is known to be far from the truth. Investigations have shown that no major change takes place in the crystal structure of the metal, although the true cause of fatigue failure is not yet fully understood.

The fatigue allowable strength varies with the desired life. This relation is best shown by an S-N diagram, such as Figure 4, where stress is plotted as the ordinate and life (number of cycles) to failure is plotted as the abscissa. The results of fatigue tests are usually recorded on logarithmic coordinates because on this type of graph the plot of the data may be represented by straight or slightly curved lines.

The portion of the S-N curve that

Fig. 5. Examples of redesign of rod ends to prevent fatigue failure.



is of most interest to the designer of aircraft hydraulic cylinders is the high-stress short-life portion between 20,000 and 100,000 cycles. This must be the minimum life expectancy of most of the parts being designed. The curves shown in Figure 4 represent the minimum life for a given reversed stress; that is, they represent the lower limits of the scatter bands obtained by plotting the results of a number of series of rotating beam fatigue tests. The curve for smooth parts refers to such parts as piston rods or the grip section of attaching bolts. Any irregularity in the surface, such as a tool mark, screw thread, or an abrupt change of section without adequate fillets, will reduce the fatigue strength of the part. This is particularly true for the high-strength aluminum alloys because of their notch sensitivity. The allowable fatigue strength for parts with the more common notches and fillets is given by the curves for notched specimens.

The Prevention of Fatigue Failure of Rod Ends

The following paragraphs will discuss ways of reducing the danger of fatigue failure of rod ends. First, the stress analysis must consider all stresses in the part. The stresses due to the cylinder design load are easily calculated. The stresses caused by bearing friction are sometimes more difficult to visualize. For a long time it was thought that with adequate lubrication the bearing friction would be low and could be disregarded. Recent experiments by the author have shown that with the high bearing loads common in current designs of aircraft actuating cylinders, the bearing friction of the plain (bushing type) bearings produces a torque moment of considerable magnitude. Because the movement of the rod end relative to the attaching bolt is both slow and oscillating, lubrication is not as effective as in more conventional bearing applications where the shaft rotates at high speeds in one direction. The slow oscillating movement of rod end bearings does not cause a fluid pressure to build up in the oil or grease film; instead, the lubricant appears to do little more than prevent galling of the rubbing surfaces.

As stated previously, the equation $T = uRN$ has been found to give reasonable values for the torque moment. For a self-aligning bearing it is necessary to know whether the ball will turn in its housing or on the bolt. Experiments have shown that where galling does not take place, the ball preferentially will turn on the bolt rather than in the housing. This movement on the bolt occurs because the lever arm (R_1) from the axis of rotation to the surface of the bolt is usually much smaller than the lever arm (R_2) to the outer surface of the ball. Since the force to produce a given torque is inversely proportional to the lever arm, only when the coefficient of friction between the ball and the bolt is much greater than that between the ball and the housing will the ball rotate in the housing rather than on the bolt.

The tendency toward galling is lowest with dissimilar metals, such as aluminum bronze against chromium plated steel, and greatest when the same metal is used for both surfaces, such as steel against steel. Even steel against chromium plated steel will gall under high loads and inadequate lubrication. Therefore, the design should incorporate an adequate method of periodically replenishing the lubricant to all moving surfaces without disassembly of the installation.

The most critical part of the rod end; that is, the place where most fatigue failures originate, is the section from the last thread on the shank through where the section changes into the eye, or body, of the end. Stress concentrations in this region can be reduced and the fatigue life of the part increased by several simple devices, the first of which is the thread relief previously described. Secondly, a generous radius (R_4) should be incorporated in the change of section from shank to body of the rod end. The angle of transition should be less than 35 degrees (Figure 3) to prevent undue stress concentrations. Examples are shown in Figure 5 of fatigue failures of rod ends which occurred during cycle test. The final satisfactory design also is shown for comparison.

ASME Promotes Good Practice Manual

THE COMMITTEE ON HYDRAULIC and Pneumatic Systems of the Southern California Section of the American Society of Mechanical Engineers, under the chairmanship of Howard Field, Jr., is conducting two activities — the preparation of a "Recommended Good Practice Manual" for the design of hydraulic and pneumatic systems and a monthly seminar on the basic theory, applications and design of such systems. The seminar, on the other hand, is sponsored by The Institute of Aeronautical Sciences, The Society of Automotive Engineers, The American Society of Civil Engineers and the American Rocket Society as well as the Hydraulic, Applied Mechanics, Machine Design, Instruments and Regulators and Aviation Divisions of ASME. The monthly seminars are open to any engineers engaged in research, design and operation of hydraulic and pneumatic components and systems.

The two parts of the program are held separately but are mutually complementary. The "Recommended Good Practices Manual" is being prepared at the junior design engineer level. No attempt is being made to set up standards. The technical and design information is being assembled as a guide for sound practices and procedures.

The preparation of the manual is broken down into three technical groups: General Theory and Application Group; Circuits Group; and Components Design Group. Subject to the participation of qualified engineers, these groups are at work on the following:

(1) Editing
(2) Bibliography
(3) Nomenclature, diagrams and symbols
(4) Specification writing
(5) Power supplies
(6) Aircraft systems
(7) Automotive systems
(8) Farm implement systems
(9) Marine systems
(10) Machine tool systems
(11) Process control systems
(12) Electric power plant systems
(13) Governors
(14) Electrical components of hydraulic and pneumatic systems

The members of each technical

group is given a choice of subjects on which they are preparing reports in rough draft form for presentation to the committee. After the technical contents of the rough drafts have been agreed upon by the technical groups concerned, the editing group will assist the authors in preparing their drafts in final form for incorporation in the manual.

A series of six seminars, held on the last Wednesday of each month, April to September, are being held at the Mechanical Engineering Building, California Institute of Technology at Pasadena. The following subjects have been or will be considered:

April 27—"Basic Theory and Application of Hydraulic Operating and Control Systems"

May 25—"Basic Theory and Applications of Pneumatic Operating and Control Systems"

June 29—"Basic Types and Characteristics of Hydraulic Circuits"

July 27—"Basic Types and Characteristics of Pneumatic Systems"

August 31—"Selection and Design of Components for Hydraulic Systems"

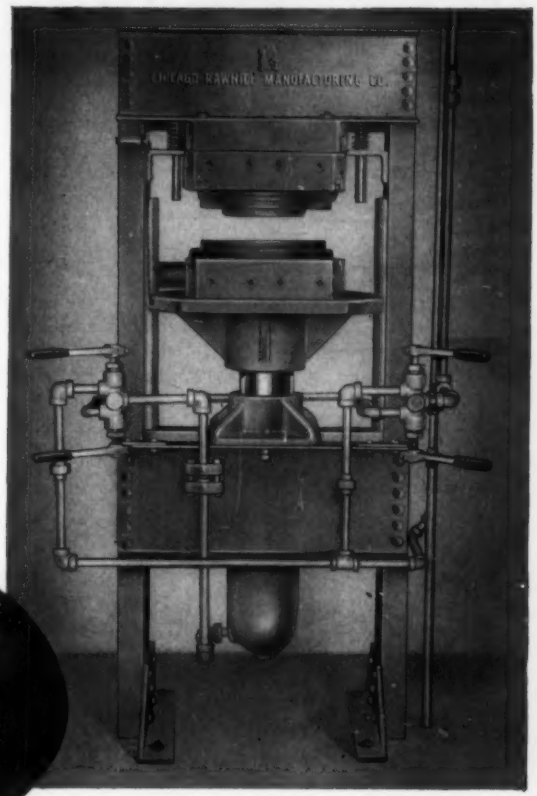
September 28—"Selection and Design of Components for Pneumatic Systems"

Leading West Coast engineers lead the discussion. For example, at the June meeting, Frank Mittell, hydraulic engineer, North American Aviation, Inc., analyzed the basic types of hydraulic operating and control circuits, described their operating characteristics and explained their suitability for different applications. An outline of the subject matter for each meeting is furnished by J. S. Newton, assistant chairman of the committee, Aerophysics Laboratory, North American Aviation, Inc., Downey, California.

Due to the scope of the program, the Committee welcomes the assistance or suggestions of any who wish to contribute on any phase of the subject matter. Mr. Field may be reached at 5959 So. Hoover St., Los Angeles 44, California. Write direct to Mr. Field or Mr. Newton. All suggestions will be given careful consideration by the Committee and the appropriate technical group and credit will be given in each case.

IN REPLACING HYDRAULIC PACKINGS

SAVE TIME and MONEY



specify sirvis

Replacing the "U" ram packing on a hydraulic press is an expensive procedure. Usually it involves dismantling the press, and the cost of installation is much greater than the cost of the packing itself. So, it's sound practice to use the best packing available. Actual tests prove that Sirvis "U" type packings deliver maximum service. On the hydraulic press illustrated, a Sirvis leather packing functions as the pressure sealing unit. Despite the extreme pressures and the action of hydraulic fluid in this application, the Sirvis packing requires less replacement than any other type. Sirvis will solve your packing problems with similar economy and service. The next time you install or replace hydraulic packings, specify Sirvis.

• *SIRVIS PACKINGS are engineered from top grade steerhide, specially tanned and treated. They are scientifically designed for all types of mechanical applications.*

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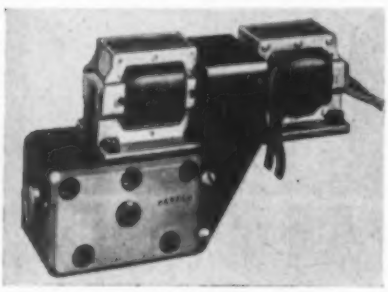
New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

Directional Control Valve

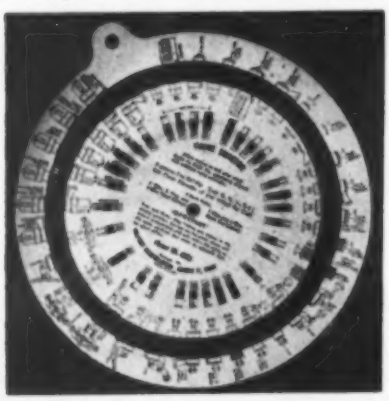
Type 89 series of double intermittent duty solenoid controlled, directional control valves offered by John S. Barnes Corporation is now available in sizes ¼ to 1½ in. The illustration



shows the smallest size of this 2-detented position, 4-way valve, designed to control remotely by electrical means the direction of flow to and from a double acting cylinder or fluid motor. The ¼ in valve has a flow capacity of 3½ gpm at 1000 psi; available also in a normally spring offset, single intermittent duty solenoid design. Standard compact Barnes solenoids permit smooth shifting. The valve may be mounted either horizontally (usual) or vertically. *1.*

Valve Selector

Valvair Corporation has just announced a valve selector, a wheel type device with code numbers for over 35,000 standard valves. Using the same principle as foreign language "verb wheels", it is just as easy to use, permitting a fast, accurate selection of



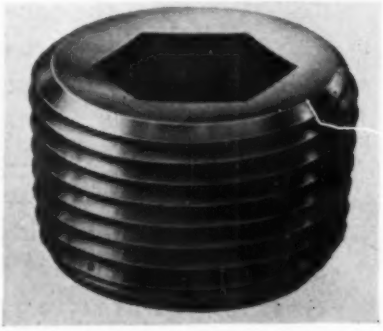
valves. Knob, lever, foot, cam, treadle, cylinder, diaphragm, tandem-operated and solenoid valves and other types are found on this selector. A price calculator is also available. The valve selector is available on request. *2.*

Feed Ring Series Cylinder

Simplicity of design with resulting lower manufacturing costs has enabled Modernaire Corporation to offer Feed Ring Series Cylinder in a new, low price range, according to an announcement made by the company. A unique locking principle eliminates threading of head to tube on both cushion and non-cushion types. Locking wire is fed into head as the head is rotated clockwise; subsequent piping of pressure line into the head through tube opening anchors both parts securely. Interchangeable mounting brackets are available to fit the requirements of practically any type installation. The use of aircraft type "O" ring packings permit inexpensive replacement of the only parts subject to wear. Non-corrosive materials used in all parts of both cushion and non-cushion models make them equally adaptable for air, water, or oil service. *3.*

Dryseal Pipe Plug

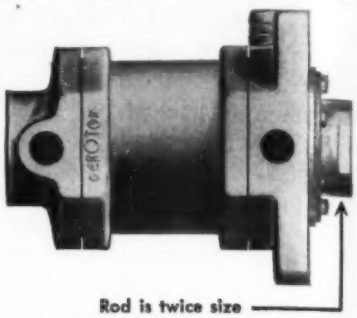
The Allen Manufacturing Company announces two new hex socket pipe plugs, which are said to eliminate the important causes of sealing failures.



Entirely pressure formed and threaded, the heads are cold drawn. The new Dryseal pipe plug is designed for use with dryseal taps and for use where a perfect seal is essential. Accurate fit is assured by 360 degrees roundness and by a perfect taper at both pitch and crest diameters. Threaded strictly in accordance with AN Aeronautical Spec. AN-P-363, sizes from 1/16 to 1¼ in are available immediately. *4.*

Cushion Cylinders

Gerotor May Corporation announces a new improved type of cushioning for its Series 100 cylinders of 150 psi air and 300 psi oil capacity. The new design provides effective cushioning of the piston stroke by compression of the displaced air or fluid. Gerotor cushion cylinders are standard cylinders employing cushion units. A cushion plate blocks off the flow of exhaust air or fluid when a cushion bushing attached to the piston rod enters the mating cushion plate. Displaced air or fluid is



compressed and metered out through adjustable needle valves. One needle valve, in the blind end cover, controls the speed of the cushioning stroke when the rod is retracting. The other needle valve, in the rod end cover, controls the speed of cushioning when the rod is extending. Two check valves built into the cushion plates permit unrestricted flow of pressure into the cylinder. Cushion air cylinders are available with cushioning on either or both cylinder ends in sizes 1½ to 12 in bores in all standard mountings. *5.*

CIRCLE NUMBERS ON THE CARD AND MAIL!

Standard Screw and Wire Gauge

The Dayton Rogers Manufacturing Co. is offering for distribution without cost a standard screw and wire gauge made of good quality steel and carefully finished to size. It will indicate screw sizs #0 to #14, wood or machine screw sizes, and measure diameters from 1/32 to ¼ in. *6.*

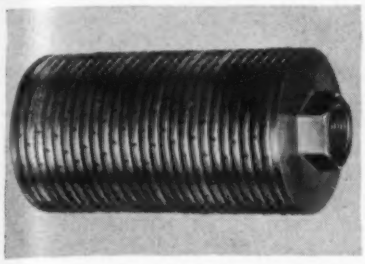
Single Plunger Control Valves

An entirely new line of small single plunger air and hydraulic control valves, announced by C. B. Hunt & Son, Inc., the Series "O" (piped exhaust) and "OE" (open exhaust) valves are extremely simple in design, sturdily built of the best materials and operate with a minimum of effort. They are well suited for use with manually controlled presses, pilot circuits and other processing cycles which involve frequent manual operation. These valves suited for air, oil or water at

pressures to 125 psi, are furnished tapped for either ⅛ or ¼ in pipe connection and are available in 2-way, 3-way open exhaust, 3-way piped exhaust, double 2-way, 4-way and 5-way designs, with either push-pull or push and spring return actions. *7.*

Wire Mesh Oil Filter

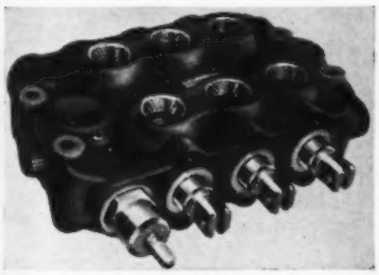
A new type lower priced industrial filter for hydraulic and lubricating oils is announced by General Filters, Inc.



The new model 1300 filter consists of a series of spacers and fine mesh screens or other filtering media. By varying the mesh of the screens, the exact degree of filtration between .040 in and 5 microns is obtained; flow rate is controlled by adding or subtracting screens and spacers. Since the removal of one nut gives access to spacers and screens, maintenance is very simple. The screens may be washer in any suitable solvent. *8.*

Large Volume Control Valves

Hydraulic Equipment Company announces its new series V8 Oil-Hydraulic Control Valves for large volume oil-hydraulic systems for road building and earth-moving machinery, heavy-duty industrial equipment and hydraulic presses. Design features include the



HYDRECO Hollow-Plunger construction with built-in check valves and adjustable differential type relief valves. Various models are available for operating up to as many as three single-acting or double-acting hydraulic cylinders. The V8 series valve will handle 80 gallons of oil per minute at operating pressures up to 1000 psi. *9.*

Swivel Connectors

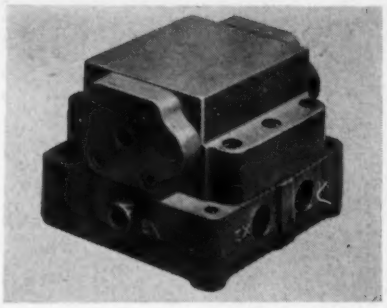
A completely new line of air-tight swivel connectors, designed for use with all types of compressed air-operated tools, has been announced by The Cleveland Vibrator Co. The new Cleveland connectors provide a full 360-degree swivel action, which increases operator efficiency and eliminates wrist strain and hand cramping. The connectors facilitate rapid and easy changing of tools and provide for increased hose life by eliminating unnecessary kinking and buckling of air feed lines. The swivel connectors are fabricated of rust-resistant steel, in straight or "ell" types to fit hoses from ¼ to 1 in and pipe from ⅛ to 1 in. *10.*

Oil and Grease Absorbent

A new low-cost oil and grease absorbent—Penn Drake KWIXORB—is now being offered by Pennsylvania Refining Company. The granular, non-inflammable, chemically inert material absorbs and picks up spillings in excess of its own weight. The manufacturer claims that Kwixorb eliminates 98 percent of the hazards of slipping, saves money in keeping floors clean and ends fire hazards from inflammable spillings. *11.*

Four-Way Air Valves

A new four-way Mastair Valve of the balanced spool type, controlled by one four-way or two three-way pilot valves, is announced by Hanna Engineering Works. Because of straight line piping, few fittings are needed; pipe may be connected to bottom or sides or parts



removed without disconnecting pipe—spool and sleeve assembly is easily taken out by removing end caps. The new valve is available in capacities of ⅜, ½, ¾ and 1 in, fully rated pipe size. Control valves are available in cam, lever, push-button and foot operated types. *12.*

(Continued on page 34)

Eliminate extra piping and welding—use the shortest and least restricted line to your burners. Full 360° positioning of the new Lindberg-Fisher Blower enables you to connect it in a hurry—at the least possible cost.

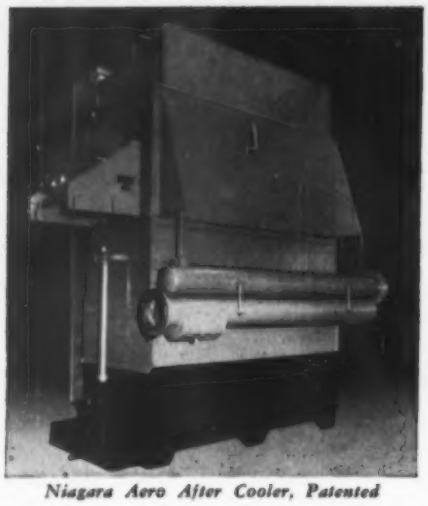
Blower housing and base are light and sturdy. The streamlined curves of the housing result in smooth and efficient operation. The dynamically balanced radial vane impellor, mounted directly on the motor shaft, is the only moving part of the Blower.

Standard 3600 RPM N.E.M.A. frame motors are used exclusively—replacements are as convenient as your nearest motor supplier. Blowers are available from 60 to 2100 CFM. "V" belt drive and combination oil pump models are available when needed.

Ask for Bulletin 740 for full information on pressures, volume, and dimensions.

LINDBERG Fisher BLOWERS

Lindberg Engineering Co., 2441 W. Hubbard St., Chicago, Ill.



Niagara Aero After Cooler, Patented

How to PREVENT CONDENSATION in COMPRESSED AIR LINES

● Users of pneumatic tools and machinery spend thousands of dollars on repairs and suffer much interruption to production from the condensation of water in their air lines. In compressed gas systems and in processes where compressed air is blown directly on parts and materials in production, there is additional damage.

You can prevent these losses by installing a Niagara Aero After Cooler. It cools the compressed air or gas by evaporative cooling and removes the water before the air enters the receiver. This method brings the air to within a few degrees of the wet bulb temperature, making certain that your compressed air will always be colder than the atmosphere surrounding the lines in your plant, so that no further condensation can take place.

Savings in cooling water pay for the installation. Experience shows that the patented Niagara evaporative cooling method consumes less than 5% of the water required for cooling by conventional means. You save the cost of the water, the cost of pumping it, the cost of disposing of it. These extra savings soon pay for the Niagara Aero After Cooler.

Write for Bulletin No. 98

NIAGARA BLOWER COMPANY

Over 35 Years of Service in Industrial Air Engineering

Dept. AH, 405 Lexington Ave.
New York 17, N. Y.

District Engineers in Principal Cities

INDUSTRIAL COOLING HEATING • DRYING

NIAGARA

HUMIDIFYING • AIR ENGINEERING EQUIPMENT

AIR-HYDRAULIC TEAMWORK

(Continued from page 10)

gency stop switch. Figure 12 shows how these stops operate.

The emergency stops at the hoists have demonstrated their value on several occasions, one of which saved a life. A new man, for some reason, had leaned on the hoist while a load was approaching from behind him. The lower valve, Figure 12, is mounted on a lever which rises against a stop in its upright position and is held there by a spring. This lever is free to move down toward the horizontal, which actually happened and trapped the man between the approaching load and the valve. Fortunately, the contact of his body caused the valve to operate and shut off the system before any injury was caused.

The stop and check valves on the loading and unloading hoists were not positive in return, due to dirt conditions. We designed and added a mechanical spool return, which in service, has never failed. This valve has to work within a definite time interval to assure success of loading and unloading.

The total number of air and hydraulic circuits on this system is in itself impressive. In the system are 60 two-way, 135 three-way and 42 four-way air valves in addition to 20 pilot operated three-way air valves, 14 lever operated and 11 pilot operated hydraulic valves and two stop and check valves, 95 small air cylinders, 22 large air cylinders and 10 hydraulic cylinders.

Every piece of air or hydraulic equipment has justified its choice in service. Some air and hydraulic cylinders have gone three million or more strokes without repairs. Maintenance has been very low.

We cannot pass the opportunity to state our appreciation to the R. C. Neal Company, Inc., of Buffalo, who furnished the hydraulic pumps, all the hydraulic cylinders, the air cylinders (and parts for those we built ourselves), all hydraulic and air valves and practically all other control and accessory equipment. During our critical days, we had "behind-the-counter" privileges in selecting valves from their stock. Often it was necessary to make emergency selections of valves to doctor two-way valves into three-way valves and vice versa.

The cooperation we received from manufacturers of equipment, particularly those represented by the Neal Company, were often "beyond the call of duty". For example, the chief engineer of the hydraulic valve company rendered a great service in performing special machining opera-

Basic Hydraulics, Questions, Chapter 2

1. What is the quantity of flow in gallons per minute of a liquid passing through a pipe with a cross section of 10 square inches at a velocity of 0.77 inches per second? (One gallon contains 231 cubic inches.)
2. What is the velocity of flow of a liquid passing through a pipe with a cross section of 5 square inches at the rate of 20 gallons per minute?
3. What is meant by unsteady flow? By streamline flow? By turbulent flow?
4. Why is pressure necessary to cause flow?
5. How much pressure is required to cause flow through a pipe 100 feet long if friction causes a pressure of 2 pounds per square inch for every 5 feet of pipe?
6. What are the five physical factors capable of acting on a liquid in a hydraulic system?
7. What is the relation between inertia, velocity and pressure?
8. What is the relation between input and output factors in a hydraulic system?
9. What factors enter into losses through friction in a hydraulic system?
10. What is the static pressure just beyond the point of exit from a hydraulic system?
11. Can the static pressure in a hydraulic system increase, without an increase in applied force, as one moves along the direction of flow?
12. What is meant by water hammer? How can it be avoided?
13. What are the indispensable parts of a working hydraulic system?
14. What is a schematic diagram? What uses can be made of such diagrams?

(For Answers to Problems, see page 40)

tions to suit special conditions. With his assistance we designed a special linkage, since adopted as standard, to get longer travel of linkage with standard spool travels. Special dust covers were designed for our conditions. In addition, he made plane trips to our plant on two occasions, each time preventing production delays which would have occurred had procedure been along normal channels.

At the time we were ready to start the system, we needed an air cylinder to push a container onto the loading hoist at a rapid rate to pick up a few seconds lost in a previous operation. A personal call to the president of the cylinder manufacturer brought us a special cylinder within 24 hours. We learned afterwards that the president had personally supervised the construction and then, because of a trucker's strike in his city, he himself had delivered the cylinder to the airport.

Another company which fabricated a large part of the hopper, container and spout work assigned two men to work with us. These men worked on my verbal orders without a purchase order. When their quota of work was complete, this company accepted without question our purchase order made from our inventory.

An interesting side light was developed with the representative of the scale company with whom we worked with the weighing station set up. He was skeptical. His remark was "this I want to see". So after the system was in operation, he was invited to see it. He looked at the system for a few minutes and then remarked, "I don't believe it."

All this is representative of the splendid cooperation we received, cooperation without which serious delays would not have been avoided.

In the automatic batch system described, the flexibility and adaptability of air and hydraulic circuits for both power movements and control have proven to be real advantages. Individual circuits are, for the most part, simple and practically fool-proof. The system has leveled out mill production at a higher rate, has practically eleminated the human error from the feed operations, improved working conditions including safety, and in the last analysis, it has resulted in very substantial savings in production costs.

Miller
Air Cylinders
Hydraulic Cylinders
SOLID STEEL HEADS, CAPS, AND MOUNTINGS — MACHINED FROM SOLID BAR STOCK
HARD CHROME PLATED PISTON RODS
DIRT WIPER SEALS
No Broken Castings
No Scratch-Damage
to Piston Rods, Bushings
and Seals . . .
therefore . . .
NO COSTLY "DOWNTIME" - NO REPAIRS
NO MAINTENANCE - NO POWER WASTAGE

SOLID STEEL HEADS, CAPS, MOUNTINGS. Dependable protection against the breakage that commonly occurs in "cast" cylinders when subjected to heavy shock loads in normal operation and when subjected to eccentric loads developed by cylinder misalignment. Eliminate "porosity" of castings. *Standard construction on all Miller Air Cylinders and Hydraulic Cylinders.*

HARD CHROME PLATED PISTON RODS. 90,000 to 110,000 psi yield point heat treated stress relieved steel accurately ground, polished, then *hard chrome plated.* Highly resistant to the nicks and scratches that commonly cause power wasting leakage. *Standard construction on all Miller Air Cylinders and Hydraulic Cylinders.*

DIRT WIPER SEALS. Wipe piston rods clean on every "in" stroke, protecting piston rods, seals, and bushings from scratch-damage by dirt, scum, abrasive particles. Easily replaceable. *Standard construction on all Miller Air Cylinders and Hydraulic Cylinders.*

Complete Line

- AIR CYLINDERS 1½" to 20" Bores
- LOW PRESSURE HYDRAULIC CYLINDERS 1½" to 12" Bores
- HIGH PRESSURE HYDRAULIC CYLINDERS 1½" to 12" Bores

Single and Double Acting, Single and Double Rod End, Spring Return, Cushioned and Non-Cushioned, Over-Sized Rod, and Long Stroke Cylinders in All Mounting Styles.

write for

Miller Air Cylinder Bulletin A-105 and Miller Hydraulic Cylinder Bulletin H-104

MILLER MOTOR COMPANY

4029 N. KEDZIE AVE. • CHICAGO 18, ILLINOIS

AIR AND HYDRAULIC CYLINDERS · ACCUMULATORS · COUNTERBALANCE CYLINDERS · BOOSTERS · AIR HOISTS

Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

28. Hydraulic Products . . . A new eight-page folder, just issued by the Commercal Shearing & Stamping Co., lists the oil hydraulic products they manufacture. Included are pumps and motors, valves, cylinders and manually operated units. This company is a major manufacturer of multiple sleeve or telescopic cylinders. Gear pumps in capacity from 1 to 75 gpm for operating pressures to 1000 psi; unit, tandem and special valves of spring or poppet types for single, double acting cylinders and hydraulic motors; telescopic cylinders from 1¾ to 11½ sleeve diameters and single sleeve single and double acting cylinders 1 to 10½ sleeve diameters; and double acting hand pumps for pressures to 5000 psi are shown.

29. De Laval-Imo Pumps . . . Catalog L-31P-A, describing the Series 31P De Laval-Imo pump, is available from the manufacturer, De Laval Steam Turbine Company. The features of this design: compactness, extreme quietness, continuous flow, operation at motor or turbine speed, no valves or pilot gears and only three moving parts are illustrated and described. Six sizes in three cases are available for delivery of 2.3 gpm at 100 psi to 50.2 gpm at 500 psi. Tables giving delivery and brake horsepower of three viscosity ranges are included. Illustrations show a number of typical installations.

30. Two Stage Compressors . . . Data sheets on the new Quincy model 390, vertical, air cooled, two stage compressor have just been issued by Quincy Compressor Co. Designed for maximum continuous pressure of 200 psi and displacement of 49 to 89 cu ft, other data in detail is given in the sheets. Base mounted and tank mounted automatic units are described.

31. Engineering Data Book . . . C. P. Clare & Co. gives full specification data on their line of relays and allied control apparatus in their 48-page Clare Relays Engineering Data Book. Basic types of Clare "Custom-Built" relays, special features to meet unusual requirements, keys, contacts and stepping switches are given. Mounting arrangements are shown in detail. Coil data is given in table form. The data book is a complete and handy guide for proper relay selection.

32. Leather Packing Form . . . Chicago Belting Company has issued a "Leather Packing Analysis and Specification Form" on which the five major types of leather packings—cup, flange, "U", 90 and 60 degree "V"—are illustrated both as to dimension and application and on which data on pressure medium, pressure ranges and maximum temperatures can be recorded. On the reverse side space for recording details of special conditions is provided. The form was prepared to be of particular utility for maintenance men, engineers and designers and to eliminate confusion and to assure the customer of the right packing for a specific application.

CIRCLE NUMBERS ON THE CARD AND MAIL!

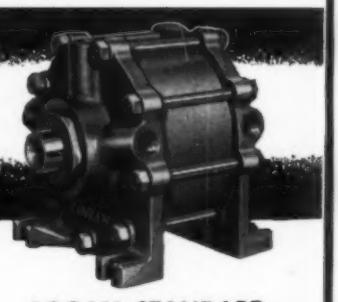
33. Universal Cylinders . . . Series 300 Airoyal universal cylinders for pneumatic service to 150 psi or hydraulic service to 1500 psi are described in a four-page bulletin issued by Com-

(Continued on page 33)

* Fluid Power Improves Production

"LOGAN" AIR CYLINDERS

STANDARD AND HEAVY-DUTY MILL-TYPE



LOGAN FEATURES THAT ASSURE PEAK PERFORMANCE AND LONG LIFE . . .

- Larger ports for quicker response.
- More sturdy construction.
- Standard models available with or without cushioning.

Fast-Acting, Positive Controlled Power . . . At Low Cost

7 STANDARD MOUNTING TYPES

Standard sizes from 1½" to 12" bore; maximum stroke, 18 feet.

Special to meet your requirements.

* ENGINEERING COUNSEL

Consult our engineers.
No obligation.

Write for FREE CATALOG

Get your free copy of catalog containing complete information on Logan air cylinders, control valves and air accessories.

LOGAN STANDARD AIR CYLINDERS

Replace most manual operations . . . eliminate human error.

LOGAN HEAVY-DUTY MILL-TYPE AIR CYLINDERS

For steel mill or aluminum extrusion mill, foundry and heavy-duty service.

Logan SAVES * TIME * EFFORT * MOTION

Air and Hydraulic Equipment

LOGANSPORT MACHINE CO., INC. 832 Center Ave. Logansport, Ind.

FLUID POWER SPECIALISTS SINCE 1916

BAKER BROTHERS, INCORPORATED

Hydraulic Feed Units

Baker Brothers, Inc., manufacturers of drilling, tapping, keyseating and contour grinding machines, offer a number of standard hydraulic feed units for single and multiple spindle operations, including a vertical hydraulic feed drill. All of these machines are equipped with one or more separate, mobile hydraulic pump and tank units, a feature which enhances the flexibility of applications, reduces down time and assures efficient cooling of the hydraulic fluids.

17 HO Vertical Hydraulic Feed Drill

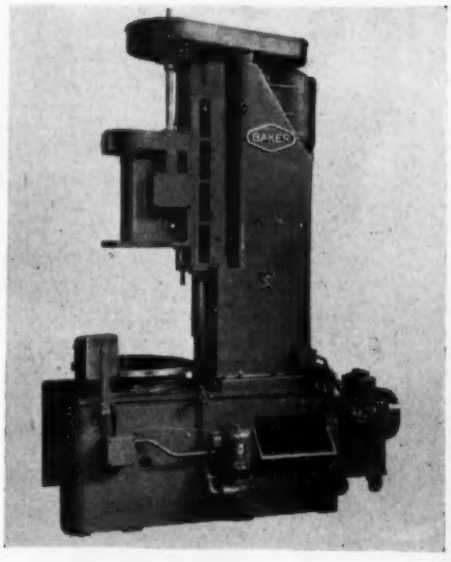
General: Moded 17 HO has ample power (7½ hp for 1200 rpm or 10 hp for 1800 rpm) to drive a 2 in high speed steel twist drill in SAE 1035 steel. The unit is adaptable to single and multiple spindle operations. Pick-off gears provide spindle speeds from 40 to 1575 rpm. The 17 HO drill is furnished with a 30 in diameter indexing table, which may be automatic, as illustrated, or hand operated. A non-indexing, adjustable height table is also available.

Specifications: Engineering Data Circular No. 69216.

Hydraulic Circuit: Feed operating cylinder 3¼ in provided with maximum feed pressure of 7300 lb, saddle feed rates 1 to 17 ipm. The cylinder powered by separate portable pump-sump unit (see below).

Attachments Available: Multiple head adaptor plate—Circular No. 69216; power index table—Data Sheet 70787; hand index table—Data Sheets 70805 and 70797.

Operation and Maintenance: Engineering Data Circulars Nos. 69216, 70949.



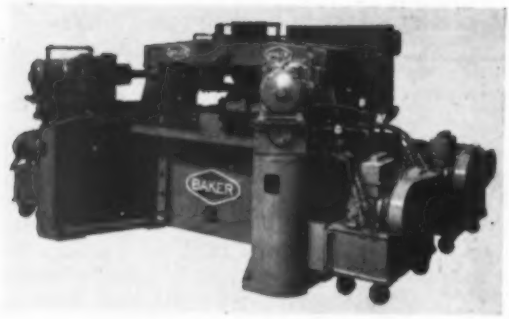
Portable Hydraulic Power Unit

General: Separate, mobile (caster mounted) hydraulic pump and tank unit, attached to operating cylinder of machine by high pressure hose lines equipped with self-sealing couplings. The unit may be attached to any hydraulic feed machine with the cycle—rapid traverse forward, feed, rapid return and neutral, and within its rated maximum delivery of .14 cu in per revolution at 1000 psi. This unit is supplied as standard on Baker drills and feed units.

Specifications: Engineering Data Circular 70949.

Hydraulic Circuit: Oilgear model JK 10203 variable delivery pump (positive displacement, radial piston type) and integral gear pump for traverse action. Built-in, solenoid operated valves are controlled by limit switches from motion of any slide or saddle. Pump, valves and 2 hp 1800 rpm motor are mounted on a 12 gal sump tank.

Operation and Maintenance: Engineering Data Circular 70949.



Model No. 3 x 12 Hydraulic Feed Unit

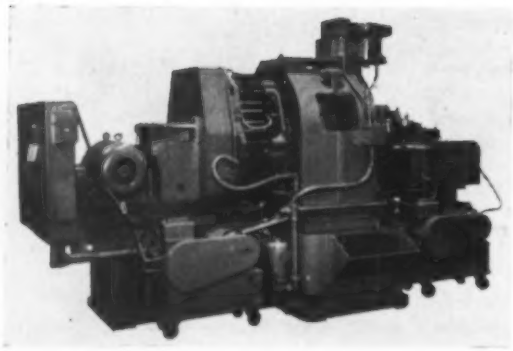
General: The 3 x 12 saddle unit has standard driver box with speed change gears and direct drive from 1 to 3 hp motor and can be mounted in horizontal, vertical or angular planes. Like all Baker hydraulic feed units, it is adaptable for single or multiple head applications. The unit is frequently used in multiple; illustrated is a four-way horizontal machine with a single position, box-type fixture.

Specifications: Engineering Data Circular 69946.

Hydraulic Circuit: Feed operation—the 2¼ in cylinder is provided with maximum feed pressure of 3000 lb. Location of hydraulic lines is optional. The standard Baker portable pump-sump system is used.

Attachments Available: Engineering Data Circular 69946.

Operation and Maintenance: Special data sheets, submit serial number of machine.



Model No. 7½ x 16 Hydraulic Feed Unit

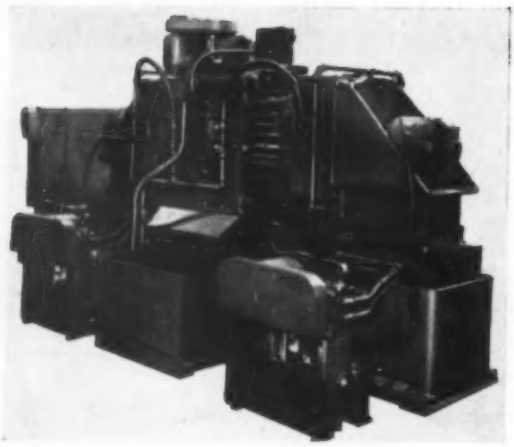
General: This unit is designed for application with special high production way type machines and may be mounted in a horizontal, vertical or angular plane. Standard driver box provides for pick-off speed change gears and V-belt drive from 5 or 7½ hp motor. Saddle feeds 1 to 17 ipm, average rapid traverse speed 194 ipm.

Specifications: Engineering Data Circular 66972.

Hydraulic Circuit: Feed operation—the 3¼ in cylinder is provided with 7300 lb maximum feed pressure. Standard Baker portable pump-sump system is used.

Attachments Available: Engineering Data Circular 66972.

Operation and Maintenance: Special data sheets, submit serial number of machine.



Model No. 15 x 16 Hydraulic Feed Unit

General: Similar to 7½ x 16 unit, except larger—with 4¼ in cylinder driven from a 7½, 10 or 15 hp motor. This unit is also used in multiple or in combination with other size feed units for multiple operation production work.

Specifications: Engineering Data Circular 66955.

Hydraulic Circuit: Feed operation—the 4¼ in cylinder is provided with 12,419 lb maximum feed pressure. Standard Baker portable pump-sump system is used.

Attachments Available: Engineering Data Circular 66955.

Operation and Maintenance: Special data sheets, submit serial number of machine.

GENERAL INFORMATION

Engineering Data Circulars are available on request from Baker Brothers, Inc., P. O. Box 101, Station F, Toledo 10, Ohio. For replacement parts or service information give serial number of machine.

All Baker Brothers machines, attachments and accessories are protected by issued and pending United States and foreign patents.

SAVE THIS VALUABLE REFERENCE MATERIAL: BUILD UP A PERMANENT FILE

(Continued from page 30)

pressed Air Products. Airoyal cylinders are designed to the irreducible minimum in size with adequate strength to permit use in restricted spaces. Available in both single-acting and double-acting types, single-acting cylinders are regularly furnished for push strokes with internal springs and strokes to 3 in, double-acting cylinders are furnished with any stroke desired. The cylinders are available in 1 and 1½ in bores for air, oil or water operation.

34. Hydreco Catalog Sheets . . . The Hydraulic Equipment Company has issued two new sections for their catalog binder: a four-page section on their V15 Series Valve, a 5 gpm, 1000 psi unit with one to three plungers to control individually single or double-acting hydraulic cylinders and designed especially for tank mounting; and a two-page section on their TV30 Combination Tank and Valve Unit, designed for 14 gpm maximum capacity and equipped with V1 Series Type B valve available with one to three plungers for operating single-acting or double-acting cylinders.

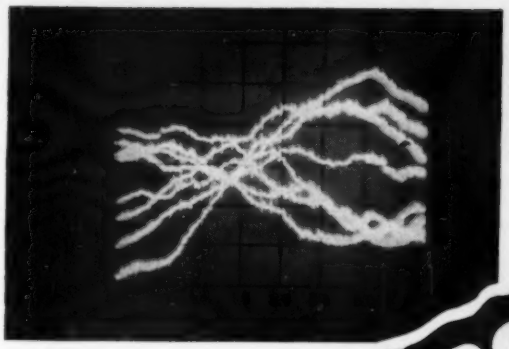
35. Pressure and Vacuum Gauges . . . The Brown Instruments Division, Minneapolis-Honeywell Regulator Company Catalog No. 700 lists the types of indicating, recording and controlling gauges offered by them. The 32-page catalog pictures and describes in detail the actuating elements, the control components (electric and air-operated), the full line of pressure gauges, high vacuum gauges, pressure regulator and flow meter and pressure gauge. Pressure gauge charts, eccentric indicating scales and a diagrammetic chart showing operating ranges of various types of instruments are included.

CIRCLE NUMBERS ON THE CARD AND MAIL!

36. Handbook for Care of Centrifugal Pumps . . . This revised handbook on the care of all makes of centrifugal pumps is now ready for distribution by Allis-Chalmers Mfg. Co. The 16-page bulletin tells the how and why of pump construction and their effect on pump maintenance; how to figure head and gives causes and cures for various sources of trouble. The fundamental facts on cavitation and how to protect pumps against it, common mistakes in packing stuffing boxes, the role of water as a lubricant and a new maintenance timetable are included. The bulletin is well illustrated with numerous sketches.

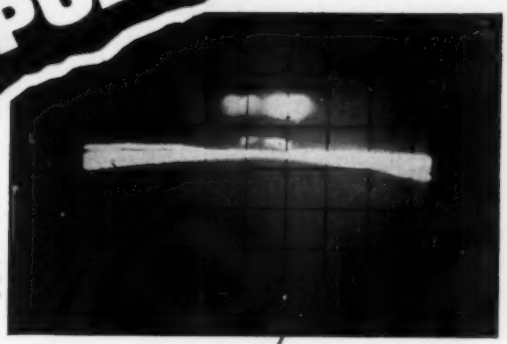
37. Hydraulic Pipe Bender . . . Bulletin E-201, "Greenlee Benders", a 16-page pocket size catalog shows the line of hydraulic pipe benders made by Greenlee Tool Co. Two standard sizes, No. 770 for bending conduit and pipe from 1¼ to 3 in and No. 775 for bending sizes from 3 to 4½ in, are described.

(Continued on page 36)



BEFORE INSTALLATION OF ACCUMULATOR
Horizontal graduations equal 50 psi and full sweep equals 0.3 seconds. Without accumulator the maximum pressure swing of the surging fluid is 350 psi.

HOW TO IRON OUT PUMP PULSATIONS



AFTER INSTALLATION OF ACCUMULATION
Same installation with accumulator in system, the maximum pressure swing was reduced to 20 psi.

Pressure surges and pump pulsations are the two most common causes of pipe lines and hydraulic system failures. Surges and pulsations, however, can be greatly minimized or eliminated by installing a Greer Accumulator in the system. A simple "T" connection is all that is necessary to install it in any existing or newly designed circuit.

The "Before" and "After" photographs above give vivid proof of the effect of accumulators in hydraulic systems. A hydrauliscope and camera attachment were used to photograph the surges and pulsations of an actual pumping circuit. The "Before" picture shows the high degree of pulsations in the line not using an accumulator. The "After" picture shows how these surges and pulsations were effectively ironed out and virtually eliminated by the use of an accumulator.

Similar tests can be performed in your own system to demonstrate the effectiveness of a Greer Accumulator.

A request for further information on your company letterhead will bring an immediate reply. Write today!

United States Patents Under Olear Licenses

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

YOUR SYMBOL OF SERVICE

GREER

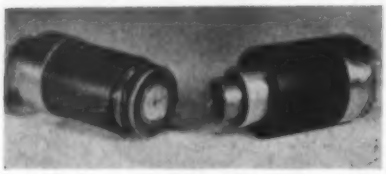
HYDRAULICS INC.

454 EIGHTEENTH ST., BROOKLYN 15, N. Y.

(Continued from page 27)

Breakaway Coupler

A quick-disconnect coupler, for use on all types of hydraulically activated implements, has been produced by the B A Coupling Co., Incorporated. The patented coupler has been field and laboratory tested by leading tractor



manufacturers and is said to offer a number of advantages including: both ends "flush" when disconnected; it can be recoupled by hand under maximum dynamic pressure; low pressure loss (15 psi with 6 cpm at 1500 psi on a ⅜ in line); free swivel action under all conditions up to 4000 psi; and both halves can be connected to seal the circuit when not in use. The use of a breakaway coupler, essential in the farm tractor and implement field, may be adapted to many other mechanisms. *13.*

CORRECTION

In Clarence Johnson's article, "The Air-Powered Hydraulic Circuit" (June issue, pp 10-12, 26) the description of Figure 3 was so brief as to be misleading. The single paragraph regarding this Figure began with the statement that this figure is basically the same as Figure 1. This is not accurate since Figure 1 is a diagram of a standard air-powered hydraulic circuit, while Figure 3 is a diagram of a hydro-check, an adjustable hydraulic resistance unit used for setting up resistance in one direction of movement. Normally this is on the outward stroke of the piston; however, the unit can be supplied with resistance on the return stroke. The remainder of this paragraph refers to Figure 1.

The hydro-check, primarily designed for use with air motors and air feeds, sets up an opposed, steadying force to the forward movement of air powered devices, flattens out the natural bounce of air and provides a very smooth feeding rate under excellent control.

In operation (Figure 3, page 12, June issue) the piston rod (left) of the hydro-check is advanced by the element to which it is linked. As the piston rod advances (moves left) hydraulic oil is forced ahead of the piston, out through the top transfer tube. The rate of oil flow is controlled by a needle valve (top center); this rate of flow in turn controls the rate of the piston rod. The oil flows from left to right through the transfer tube and reenters the right or blind end of the cylinder. On the return stroke, a one way valve within the piston head opens permitting oil to flow unrestricted through the piston from blind to rod side. The small balance cylinder, shown below in Figure 3, functions as a spring pressure force reservoir to compensate for volumetric displacement of the piston, for temperature changes and for any slight oil leakage.

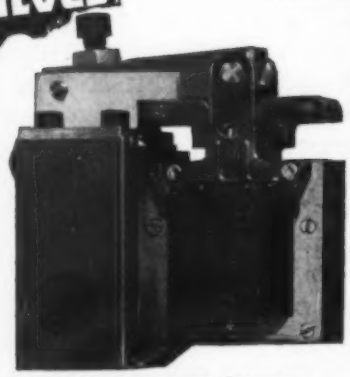
The hydro-check is adjustable and flexible. It may be set to check the rate of feed at any given point. In operation the unit permits rapid traverse of the tool to the work, controlled feeding through the work and rapid return of the tool to its initial point, making it possible to utilize the maximum productive output of all types of air powered tools and equipment.

NEW HIGH PRESSURE
SOLENOID VALVES

FOR 110-VOLT 60 CYCLE A.C. CURRENT

Features

- Rugged compact construction
- 3000 P.S.I. operating pressure
- Continuous duty
- Poppet design eliminates leakage
- May be mounted in any position
- Impregnated coils resist moisture and condensation



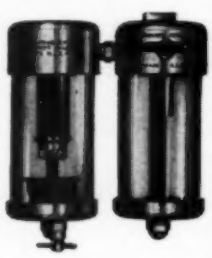
Waterman High Pressure Solenoid Valves are inexpensive, compact units designed for continuous duty in hydraulic systems where pressures are as high as 3000 P.S.I. Poppet type construction gives positive sealing against internal leakage. Impregnated oil resistant coils make these valves suitable for mounting in oil reservoirs. In many cases this feature eliminates costly piping and makes possible the construction of smaller, more compact hydraulic power units. Available in ⅜" pipe size. Electrical requirements are 110 volt—60 cycle A.C. current.

West Coast: 918 No. Kenilworth Ave., Glendale 2, Calif.

WATERMAN ENGINEERING Company

2121 CHESTER AVENUE • EVANSTON, ILLINOIS

"M-B" AUTOMATIC
Air Line FILTERS and LUBRICATORS



FILTER element removes solids .00039 and larger. TRANSPARENT BOWL provides visibility. LUBRICATOR delivers desired volume of oil, no more, no less. Adjustable Venturi Valve permits efficient operation on broad range of volume and pressure . . . Bowl can be refilled without shutting off air supply. THESE DEVICES CAN BE USED AS SEPARATE UNITS OR IN COMBINATION.

Write for Literature

Representatives in Principal Cities

M-B PRODUCTS
130-134 E. Larned St.
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LETTERS to the Editor

We have heard a lot of talk about the carryover in design of aviation hydraulic components to the advantage of designs of general industrial parts, especially valves. Actually, we have seen very little such carryover or at least we haven't recognized it. What is the situation?

J.M.
P.I.B.

Specifications and tolerances of aircraft hydraulic components are very rigid and often special and the life of any one design is frequently very short. Aviation valves, for example, are, to all intents and purpose, custom built. On the other hand general application valves can be built heavier, with ordinary commercial tolerances and made adaptable to a range of applications. Even the manufacturers who build both aircraft and general industrial components, divide the classes of work within their plants.

I missed Mr. Schupner's article on air circuit design in the March issue. I had come to expect such an article in alternate issues. Does this mean we are to have no more of Schupner?

R.N.

No, it does not; we plan to continue this series for some time. Mr. Schupner's sixth article in his series is in this issue.

On a few of the articles in APPLIED HYDRAULICS the diagrams of electrical circuits were given as well as the hydraulic circuits. Would it not be practical to publish electrical diagrams more often and couple them with the hydraulic or air circuits they control? J.P.

Several of our readers have called this to our attention. We agree that the practice of showing electrical diagrams as well as hydraulic or air circuit diagrams is a valuable and practical one. We attempt to get electrical circuit diagrams on our staff prepared articles and we ask contributors for both hydraulic and electrical diagrams.

Sometime ago we purchased a hydraulic baling machine made up to our specifications. The machine was not made by a standard hydraulic manufacturer. We would like to increase the speed of the cylinder stroke. In our inexperience, we do not know how to proceed. The cylinder is approximately 43 in long and with a bore of approximately 5½ in. A gear pump with 12 teeth OD 1.777 x 1¼ in wide (spiral) is driven by a 1200 rpm motor. The pipe line is 1½ in and the machine operation is controlled by a pressure release valve. Some of the questions we have in mind are: would we need a larger pump; a larger pump line and a larger valve? We would also appreciate any other information you can give us in helping us to adjust this machine.

You might keep in mind that we know very little about hydraulics and we have no idea where this information might be obtained. B.L.C.

We have written giving the names of two manufacturers' regional offices that do business in your territory. Readers are invited to make suggestions.

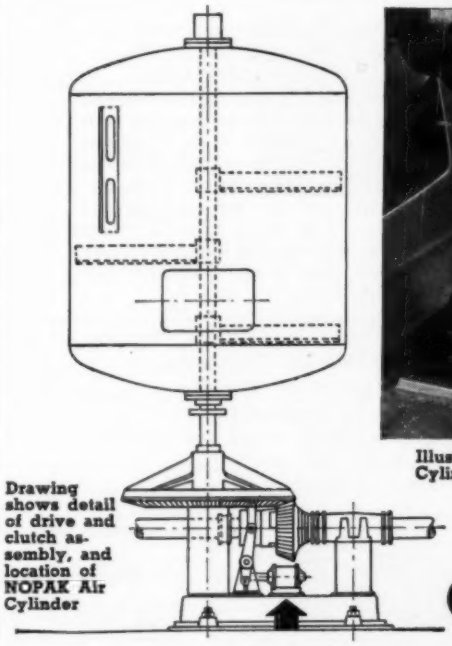
We have received a nice group of letters regarding the Aviation Hydraulic Section which began with the June issue. The following three are typical of comments made:

Allow me to congratulate you on your very excellent choice of Mr. Hosterman as advisory editor for your new aviation section.

D.B.G.

With so many good men to choose from, you certainly did a good job of persuading Fred Hosterman to act as your aviation advisory editor. Fred has always delivered the goods. R.B.T.

You are to be congratulated on the choice of Fred O. Hosterman as advisory editor for your aviation section. This makes this department "must" reading for me. J.R.

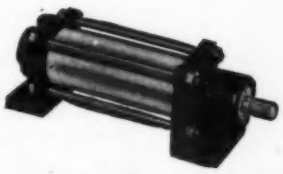


Drawing shows detail of drive and clutch assembly, and location of NOPAK Air Cylinder

Illustration shows NOPAK Model "A" 6" Cylinder which throws clutch in and out

NOPAK CYLINDERS

Actuate Meal-Extractor Clutches



NOPAK Model "A" Cylinder with Self-Regulating Cushion at both ends of stroke

At Victory Mills, Ltd., Toronto, Canada, each of 12 power-driven meal extractors is equipped with a NOPAK Model "A" 6" Cylinder to engage and disengage the clutch to the bevel pinion gear which rides on the line shaft. Power is transmitted from the line shaft, thru the clutch, to the sweep-arms inside the extractors. A NOPAK 4-Way control valve operates each of the 12 cylinders, eliminating manual effort, assuring greater dependability and smoother operation. This is but one of many power-transmission applications in which NOPAK Valves and Cylinders are serving efficiently under rugged operating conditions.

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VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

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D. E. RANDALL
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Cleveland 6, Ohio

GARRETT BURGESS, INC.
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JOHN HENRY FOSTER CO.
2850 Gravois Ave.,
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E. C. WILD
1106 So. Lincoln St.,
Denver 9, Colorado

J. M. O'BRIEN
32 No. Holman St.,
Portland 11, Oregon

TRANSMISSION ENGINEERING CO.
53 Stevenson St.,
San Francisco 5, Calif.

JOHN G. SPOTTON
4233 Dundas St. W.
Toronto 18, Ont.

(Continued from page 33)

38. Timing Motors and Devices . . . Catalog No. 321, issued by Haydon Manufacturing Company, Inc. gives full specifications and components of ten series of timing motors, rest timers, including both adjustable and non-adjustable time delay, elapsed time indicators, interval timers and direct current timers. A number of special timers and clock fit-ups are also shown.

39. Remote Controls . . . A catalog consisting of a group of loose leaf folders and drawings of various standard flexible and rigid remote controls is available from Arens Controls, Inc. Wire and combination liner types of push-pull controls are shown, as well as the Arens remote switch control, flexible control end fittings and accessories.

40. Valve and Cylinder Applications . . . Applications of the NOPAC line of hydraulic and air valves and cylinders are shown on a wide range of actual installations in an Application Manual issued by Galland-Henning Manufacturing Co. A number of NOPAC flat cored-disc valves (AOW to 250 psi), 3- and 4-way air operating valves, 2-, 3- and 4-way foot operated and solenoid operated valves, standard 500 psi hydraulic valves for oil or water and balanced hy-pressure hydraulic operating valves for service to 1500 psi, the Reciprotrol automatically operated (air or oil 50 to 300 psi) and dual 4-way valve are shown as well as 4 classes of non-rotating double-acting cylinders for air, oil or water service in class pressure ranges to 150, 375, 650 and 1500 psi.

41. Martin Electronics . . . A brochure issued by The Glenn L. Martin Company outlines the part played by this company in the development of a wide variety of electronic test equipment. While primarily concerned with military aviation projects, a Pilot Production Shop is serving special industrial needs as well. A list of test equipment gives an idea of the scope of the work that can be done for industry.

THE MARKET PLACE

CLASSIFIED ADVERTISING

Rates: For "Positions Wanted" $4.00 minimum, limit 25 words. For all other classifications $4.50 minimum for 25 words, each additional word 15c; bold face type or all capitals, $7.50 minimum for 25 words, each additional word 20c; limit 50 words. Box addresses count as five words. All insertions are payable in advance.

These columns are limited to Help Wanted or Position Wanted ads, and offerings of used equipment by the users of such equipment.

ACCOUNTS WANTED—FLUID CONTROLS

Manufacturers representative calling processing industries and manufacturing plants in Cleveland and northern Ohio wants additional line of fluid controls or instruments and related equipment to sell. Have broad application and sales engineering experience. Address Box 4918, APPLIED HYDRAULICS.

POSITION WANTED

Graduate mechanical engineer, 35. Experience includes eight years research and development of aircraft hydraulic and pneumatic equipment. Desires responsible position. Address Box 4919, APPLIED HYDRAULICS.

FOR SALE

125 ton hydraulic press, all steel, four column, knockouts, pushbacks, working area fourteen inches by fourteen. Power unit, controls, coolers. Write Box 4920, APPLIED HYDRAULICS.

DRAFTSMAN, layout and detail. Milwaukee manufacturer of hydraulic pumps, valves, and similar products has opening for an experienced man in this field. Age 30-50. State experience and salary expectation in first letter. Write Box 4221, APPLIED HYDRAULICS.

How to Boost Production with new Method of Mounting Ross Valves
★ Faster Machine Speeds
★ Less Air Consumption
★ Economical Installation
★ Easier Operation

Close-coupling of valve to cylinder! That's the story behind the remarkable success of the *new Ross In-Line Master Valve.*

Users claim several important advantages. By placing the master valves (A & B) at the cylinder (D), air supply and exhaust are speeded up appreciably. This in turn permits faster movement of the cylinder piston and materially increases production.

At the same time, the close coupling means that two lengths of large diameter piping between valve and cylinder — pipes continually filled and exhausted with non-productive air—are replaced by two short connecting pipes (F). The resultant saving in air with every movement of the piston considerably reduces operating costs.

Operation is by a small, conveniently located 3-way pilot valve (C). It is supplied through tubing (E) and connected to the master valves by tubing (G). It may be mechanically, manually or electrically controlled. Hand or foot operation is greatly facilitated by the use of the smaller, more easily actuated pilot model.

For complete details, ask for Bulletin No. 302.

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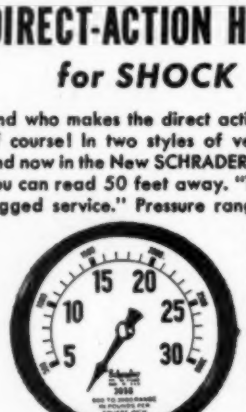
Everybody says you can't beat

DIRECT-ACTION HYDRAULIC GAUGES

for SHOCK RESISTANCE

And who makes the direct action hydraulic gauges? Schrader, of course! In two styles of vertical scale—Standard Type—and now in the New SCHRADER HYDRODIAL . . . the dial gauge you can read 50 feet away. "Truly a heavy duty unit for hard rugged service." Pressure ranges: For Hydrodial Type—5-50 up to 500-5000 lbs. per sq. in. For Standard Type—5-50 up to 1500-5000 lbs. per sq. in. These gauges are not laboratory gauges, but truly work units that are at their best in surging lines. Write for information about Schrader Direct-Action Gauges.



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Calibrations Readable at 50 Feet!
Calibration Ranges up to 5000 lbs.
Clear Plastic Face.
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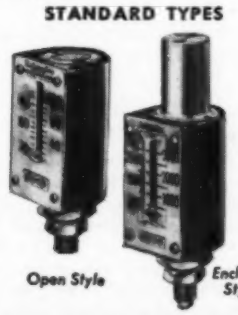

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APPLIED HYDRAULICS DIGEST

Abstracts, summaries and listings of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions pertinent to the hydraulics field.

How to Get Your Money's Worth Out of Dial Indicators

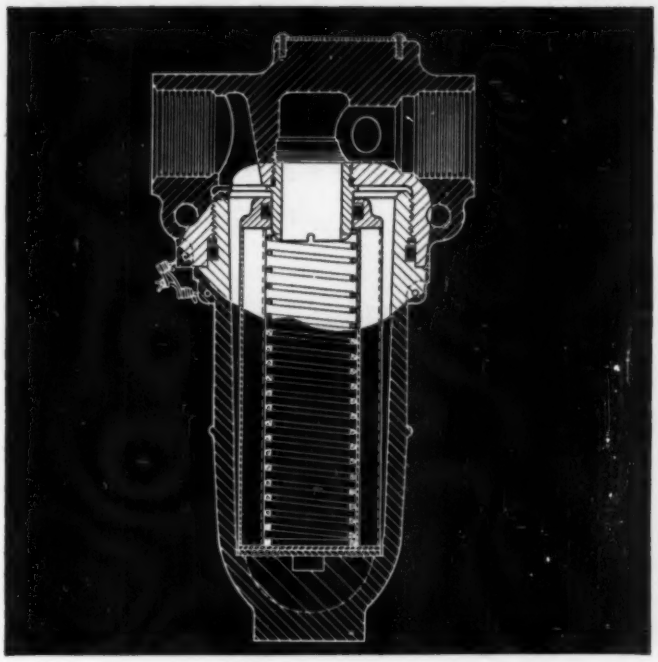
I. A. Hunt, *American Machinist,* v 93, June 16, 1949, pp 93-100.

The essential "works" of a dial indicator are shown and briefly described; standard dimensions and most generally used types of dials and some of the most common attachments available to increase the utility of the indicator are stated with applications for which they are used. The universal test indicator is also shown and described. There are sections on maintenance and checking, mounting the indicator and on when and how to use indicators.

Hydraulic Equipment of Modern Aircraft

James Robinson, from remarks made in the panel discussion, "Getting the Best Out of Our New Transports," SAE Aeronautical and Air Transport Meeting, Hotel New Yorker, New York, April 12.

The use of 3000 psi operating pressures in hydraulic systems now being flown by commercial airlines is general; acceptance tests are in progress for the military services with some pumps approved on a tentative AN specification for 3000 psi fixed displacement units and work in progress on variable displacement units. The concentration of research on non-flammable fluids will create a problem, when and if such a satisfactory final fluid is obtained, of metallurgically redeveloping many components and elements. Cabin supercharger drives of various designs are in use and under development, including a split torque system, a design in which the hydraulic motors are mounted, through gearing, directly on the compressor and a fixed speed hydraulic drive for the original cabin supercharger drive, a simple direct mechanical shaft from the engine to the compressor. The use of a variable displacement pump is suggested both to simplify and to make such a system fully automatic. Intensive studies in the servo field have greatly extended two important aspects: a prediction of the performance of a group of individual units combined as a system; and a knowledge of how each individual unit should be designed in reference to the characteristics of the other units in the system. The driving of aircraft turrets was pointed out as a specific application.



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Purolator's new aircraft hydraulic filter illustrated here uses LINEAR "O" rings to resist pressures as high as 4800 p.s.i. and temperatures from as low as minus 68°F. to as high as plus 280°F. Purolator's experience is a good example of the versatility, reliability and simplicity effected with LINEAR "O" rings.

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LaPLANT-CHOATE MFG. CO., INC.
CEDAR RAPIDS • IOWA

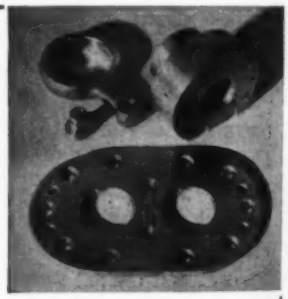
Since the advent of sonic and supersonic aircraft, greater demands for higher performance are being made on hydraulic systems. Units are being developed for contemplated use of flight control on pilotless aircraft or flying missiles. The power demands for some such systems are slightly less than 10 hp, pressures contemplated are approximately 4500 psi. The speed of hydraulic units for these applications has been increased to almost 9000 rpm. In general, the system consists of variable displacement pumps driving fixed displacement hydraulic motors.

Employee Turnover Can Be Cured

H. M. Willyoung, *Modern Machine Shop,* v 22, July 1949, pp 118-120, 122, 124, 126, 128.

The director, associate membership, Research Institute of America, Inc. begins an analysis of employee turnover problems at the supervisory or foreman level by stating that it is not unusual for 75 percent of all turnover to center on employees with a company for less than six months. The analysis is in the form of questions that should be asked and answered before requisitioning, when interviewing, after the job is accepted, the first day and the first week induction on the job. Since records indicate that turnover costs from $10 to more than $200 per individual, adequate answers are invaluable to company and new employee alike. The induction problem is carried through for a period of six months. The cooperation of the personnel department as a staff function and of the supervisory

SAVE REAL MONEY



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members as a line function is stressed. Preventing or reducing turnover is a responsibility of the supervisor of foreman, as well as identifying and checking hidden cost factors (slow learning rate, poor individual adjustment, etc.). The author recommends a careful, continuous check for a period of six months to give the new employee the clear-cut objectives of his job, the feeling that he is wanted and a sense of permanence.

How to Select and Care for Electric Motor Controls

B. Green, *Factory Management and Maintenance,* v 107, June 1949, pp 95-105.

The choices between magnetic or manual controls and full-voltage and reduced-voltage starting are pointed out and the trend toward multi-speed motor control is briefly discussed. Protective devices for undervoltage protection or release, overload and short-circuit protection and quick-stop control are shown diagrammetically. Mechanical interlocking controllers and the possibilities of the electronic tube in industry are discussed and shown in typical installations. Control accessories including solenoids, electro-hydraulic thrust mechanisms, pushbuttons, pressure and vacuum switches, pressure governors, float, limit and speed selector switches and reversing starter are included. On the care of electric motor controls a trouble-shooting and inspection chart is presented.

Special Plow Lays Coaxial Cables

Anonymous, *Excavating Engineer,* v 43, July 1949, pp 34-35.

A specially designed hydraulically driven cable plow, the C-60, or, as its operators have named it, "Mickey Mouse," is being used in many places by the American Telephone and Telegraph Co. to lay new coaxial cables for television program transmission and to step up the rate of long distance telephone messages. The 27-ton hydraulically manipulated plow cuts a slot as deep as five feet in which the cable is buried. The plow is pulled by three 20-ton tractors in tandem, more if the going is rough, and tows a trailer carrying its gasoline powered control mechanism. The hydraulic circuit raises and lowers the plowshare and swings its tip at right angles to the trench, so that the edge of the plow is at the best angle for slicing into the earth or for rimming large obstructions. A relief valve prevents damage if heavy rocks or other solid obstructions are encountered. Another feature is that a 39-in wheel, built into the plowshare, permits the cable to be passed through it and into the ground at a minimum of friction. A second trailer behind the plow carries a reel of 1000 feet of the coaxial cable. The cable contains 8 coaxial tubes, each of which is capable of handling 600 simultaneous telephone conversations or two television programs. Conceived by AT&T engineers, the C-60 was built by Arthur Rehberger & Sons, Newark, N. J. At the end of 1948 the C-60 and other plows had laid over 6500 miles of coaxial cable. Two recent jobs were the 154 mile line from New York to Albany, New York and the 153 mile line from Yakima to Seattle, Washington.

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In all of Monarch Machine Tool's lathes with "Air Gage Tracer", Resistoflex assemblies are used to assure smooth, split-second hydraulic gaging and control. For they proved to be the only lines to live up to required performance.

Once again Resistoflex hose ends a line problem.

In Monarch Machine Tool's method of duplicating work automatically, gaging of a master template is done through the medium of air. Because of the sensitivity of the "Air Gage Tracer," unrestricted, precise air flow is *imperative.* In addition, the line must withstand continuous flexing. Monarch finds the answer to both in Resistoflex hose. Not only is it immune to flexing and vibration, but, with its glass-smooth compar tube, it allows full air flow without any turbulence!

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Do you have a line problem? Discover how you can transmit oils or gases through fatigue-proof Resistoflex lines and reduce servicing. Write us about it.

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POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

Hydraulic Equipment Company, Cleveland, Ohio, announces the appointment of Robert F. Hodgson as chief engineer. He has been with the company for four years in both engineering and sales capacities. Prior to joining Hydreco, Mr. Hodgson was a member of the Engineering Department of Wright Aeronautical Corp., Curtiss Wright Corp. at Paterson, N. J.

Plastic and Rubber Products, Inc. announce the appointment of Harlan H. Davis as manager of the Chicago office. Mr. Davis was chief hydraulic engineer for Dunbar Kapple, Inc. at Geneva, Ill., where he directed the development of a line of farm tractor hydraulic systems and attachments. Robert E. Allen, vice president of Plastic and Rubber Products, Inc., who has had charge of the Chicago office for four years, has transferred his activities to the Dayton headquarters of the company.

Double A Products Co., Manchester, Mich., announces the appointment of The Weinman Pump & Supply Co., 317 S. Main St., West End, Pittsburgh 20, Pa. as representatives for the sale of the Hydraulic Hi-Speed Oil Control Valves for Pittsburgh, western Pennsylvania and northern West Virginia.

ANSWERS TO PROBLEMS

1. 2 gallons per minute
2. 15.4 inches per second
5. Over 40 pounds per square inch

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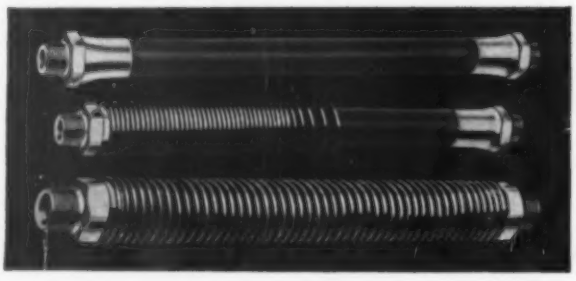
MULCONROY *Hydraulic*
HOSE ASSEMBLIES . . .



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AIR CONTROL VALVES
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Lever operated type illustrated

- NON-CORROSIVE
- NO METAL SEATS
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60 types to choose from
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